INTERN EXPERIENCE AT
THE TEXAS TRANSPORTATION INSTITUTE

AN INTERNSHIP REPORT

by

Donald Arthur Andersen

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in partial fulfillment of the requirements for the degree of

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May 1982

Major Subject: Civil Engineering

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TEXAS TRANSPORTATION INSTITUTE

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ABSTRACT

INTERN EXPERIENCE AT THE
TEXAS TRANSPORTATION INSTITUTE

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This report discusses the author's engineering experience at the Texas Transportation Institute (TTI), Texas A&M University from March 1974 through July 1977. A report on this experience plus twelve additional hours of academic course work were substituted for an internship according to requirements established by the College of Engineering.

Although the author could not retroactively establish objectives of the type associated with a typical internship, the work experience gained could be related to the two general objectives of an internship:

1. To demonstrate an identifiable contribution to the organization in which the intern served, and
2. To enable the intern to become aware of the non-technical aspects of working as an engineer in a non-academic environment.

While a member of the Texas Transportation Institute staff, the author worked on a number of projects in the areas of highway traffic engineering research and the preparation of continuing education

courses for transportation engineering officials. These assignments were contained within the Urban Transportation Systems Division of TTI. This report delineates the author's contribution to four particular projects and discusses the technical as well as non-technical experience gained from each.

Having been exposed to more engineering situations than many of the other Doctor of Engineering students, the author has already formulated some rather specific milestones for the future. The Doctor of Engineering program is discussed in conjunction with its potential for helping the author attain these career goals and objectives. Also, some thoughts are presented regarding the Doctor of Engineering as a viable alternative to the Ph.D. in preparing for a career in engineering higher education.

ACKNOWLEDGEMENTS

The author thanks everyone who assisted him in the preparation of this report and the attainment of the Doctor of Engineering. Particular recognition is due to Neilon J. Rowan, Ph.D., P.E., chairman of the author's academic committee and to the other committee members: Donald L. Woods, Ph.D., P.E.; Vergil G. Stover, Ph.D., P.E.; Peter E. Jenkins, Ph.D., P.E.; Robert J. Stalcup, Ph.D.; and Professor Arthur H. Stroud, Graduate Council Representative. Ms. Kathy Shearer, Administrative Assistant to the Dean of Engineering, is also commended for her assistance in bringing this effort to fruition.

Two individuals at North Dakota State University, Dr. Joseph Stanislao, Dean of Engineering, and Dr. James L. Jorgenson, Chairman of the Civil Engineering Department, are also acknowledged for encouraging the author to undertake and complete the Doctor of Engineering.

Ms. Caroline T. Vessels deserves special mention for typing this report.

Finally, my wife Sandra and my son Jeffrey are recognized for their patience and encouragement during this period of study.

Don Andersen　　　　College Station, Texas

May 1982

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CHAPTER I

INTRODUCTION

This is a report of Donald Andersen's professional work experience with the Texas Transportation Institute at Texas A&M University from March 1974 through July 1977. This report and twelve additional hours of course work were completed as a requirement for having the Doctor of Engineering internship waived, the conditions for which were listed in the 1976 Graduate Catalog as follows:

> Students who have had extensive engineering experience may substitute equivalent academic course credit for the internship on an individual basis, provided that they submit an acceptable Internship Report. (1)

The extent and diversity of the author's engineering experience are indicated in the body of this report as well as Appendices B and C.

Waiver of Internship

In requesting that the internship requirement be waived, the relative value of the experience to be gained from one year's internship was weighed versus the knowledge to be gained from twelve additional hours of academic course work. Regarding the first of these, it can be argued that regardless of how long a person has worked in the engineering profession, another year's work experience, if at all meaningful, will benefit the individual professionally. The one-year

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Transportation Research Record 725, National Research Council, National Academy of Sciences, Washington, D.C., 1979, has been used as a pattern for the style and format of this report.

internship is especially valuable for those Doctor of Engineering students who have spent most of their careers in an academic atmosphere and need an opportunity to apply the knowledge they have gained to real-world situations. This author, however, with over ten years of professional engineering experience, felt he had encountered many of the situations normally faced during the typical internship. Undoubtedly, some of these incidents may have been handled differently had the majority of the Doctor of Engineering program already been completed. Situations of this type are documented throughout this report.

A second consideration in requesting that the internship be waived was related to the author's long-term career goals in higher education as explained more fully in Chapter IV. The option of having the internship waived allowed for the selection of twelve more hours of courses in those subjects that the author would probably be teaching in the future. These additional hours along with the required courses of the Doctor of Engineering program should provide a substantial information base in both the technical and professional aspects of engineering education.

Therefore, the reasons for requesting that the internship requirement be waived were: (1) the relative utility of another year's work experience, and (2) the potential benefits of being exposed to additional course work.

Substitution of Work Experience

The author has had four engineering positions since receiving the

Bachelor of Science in Civil Engineering in 1970:

- Engineer 1--Nebraska Department of Roads, March 1970-February 1974.
- Asst. Research Engineer--Texas Transportation Institute, March 1974-July 1977.
- Assistant Professor--North Dakota State University, August 1977-August 1980.
- Lecturer--Texas A&M University, September 1980-Present.

This report deals primarily with the author's duties while a member of the Texas Transportation Institute (TTI). This engineering position was chosen as the subject of this report because the activities with that organization seemed to most nearly approximate those of an internship as suggested by the College of Engineering (2). The work at TTI was deemed preferable to that of the Nebraska Department of Roads because the latter tended to be of a more technical nature than that suggested for an internship. The experience in higher education at North Dakota State University was not chosen due to the academic nature of this position even though at least one individual has raised some thought provoking ideas regarding the use of college teaching as an internship environment (3). Thus the bulk of this report treats the work experience gained while at the Texas Transportation Institute.

Organization of Report

The remainder of this report is divided into four chapters followed by three appendices. Chapter II explains the purpose, structure and management concept of the Texas Transportation Institute. Chapter III is a discussion of the author's contribution to several projects and the professional benefits derived from these assignments. Chapter IV contains the author's career goals and objectives and the means by which the Doctor of Engineering has helped prepare for a career in higher education. The report is summarized in Chapter V. Appendix A is a listing of the projects in which the author participated while a member of the Texas Transportation Institute. Appendices B and C are a review of the author's professional experience with the Nebraska Department of Roads and North Dakota State University respectively.

CHAPTER II

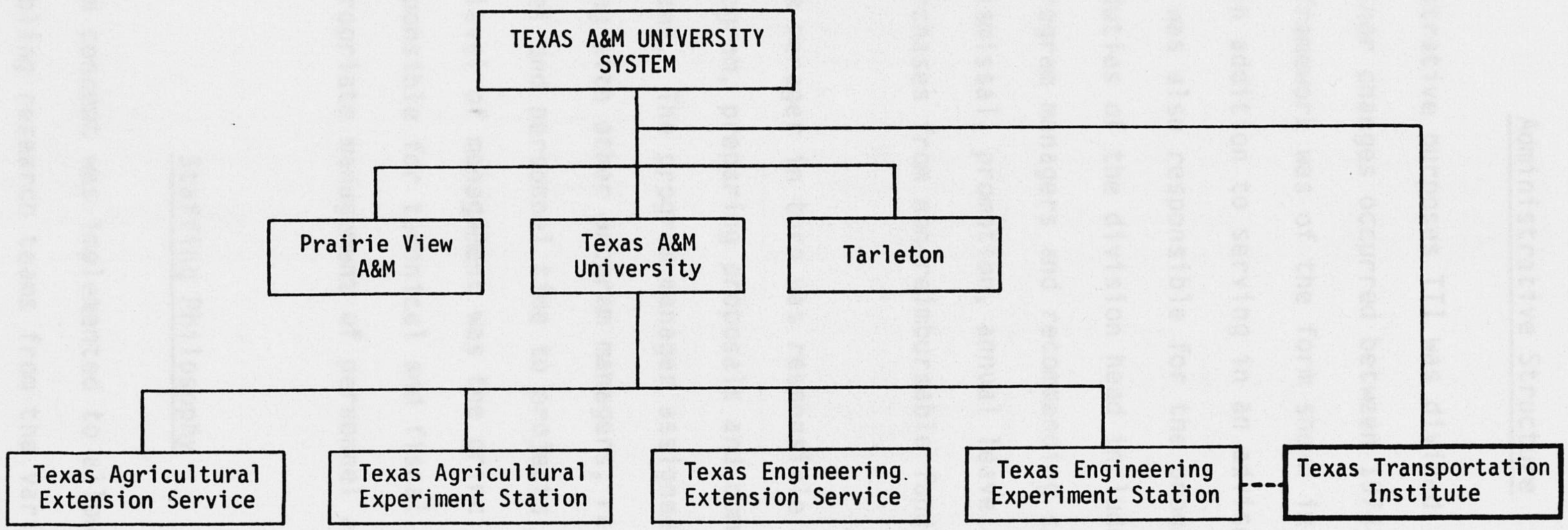
THE TEXAS TRANSPORTATION INSTITUTE

The Texas Transportation Institute, a part of the Texas A&M University System, was created in 1957 "to meet the rapidly growing technological demands." Since that time, it has continually responded to that challenge with research technology that has been adopted nationwide for the safe, efficient and economical movement of people and goods. As a public service organization the Institute conducts research in a number of modes of transportation--air, water, rail, highway and pipeline. Research results are disseminated by means of classroom teaching, training programs for practitioners, and presentations at various technical society meetings. Being a multidisciplinary organization, the programs of the Institute extend into the planning, design, construction, operation, maintenance, enforcement, safety, economics, ecological, and social aspects of transportation.

Under the legal and administrative actions establishing the Texas Transportation Institute, the Institute may contract to provide research services to other public agencies and private firms. These organizations include other state agencies, the Federal Highway Administration, other federal agencies, cities, foundations, technical societies and the National Cooperative Highway Research Program administered by the Transportation Research Board.

At the time the author was on the Institute's staff, the Institute was related to the university system as shown in Figure 1. Although the Institute was a separate entity, it shared certain personnel and facilities with the Texas Engineering Experiment Station.

Figure 1. University System Partial Organizational Chart.



Administrative Structure

For administrative purposes TTI was divided into divisions. Although some minor changes occurred between 1974 and 1977, the basic organizational framework was of the form shown in Figure 2. Each division head, in addition to serving in an advisory capacity on matters of policy, was also responsible for the programs within that division. Other duties of the division head included acquiring information from the program managers and recommending salaries and wages, employment or dismissal, promotion, annual leave, personnel assignment to programs, purchases from non-reimbursable funds, office space and inventory.

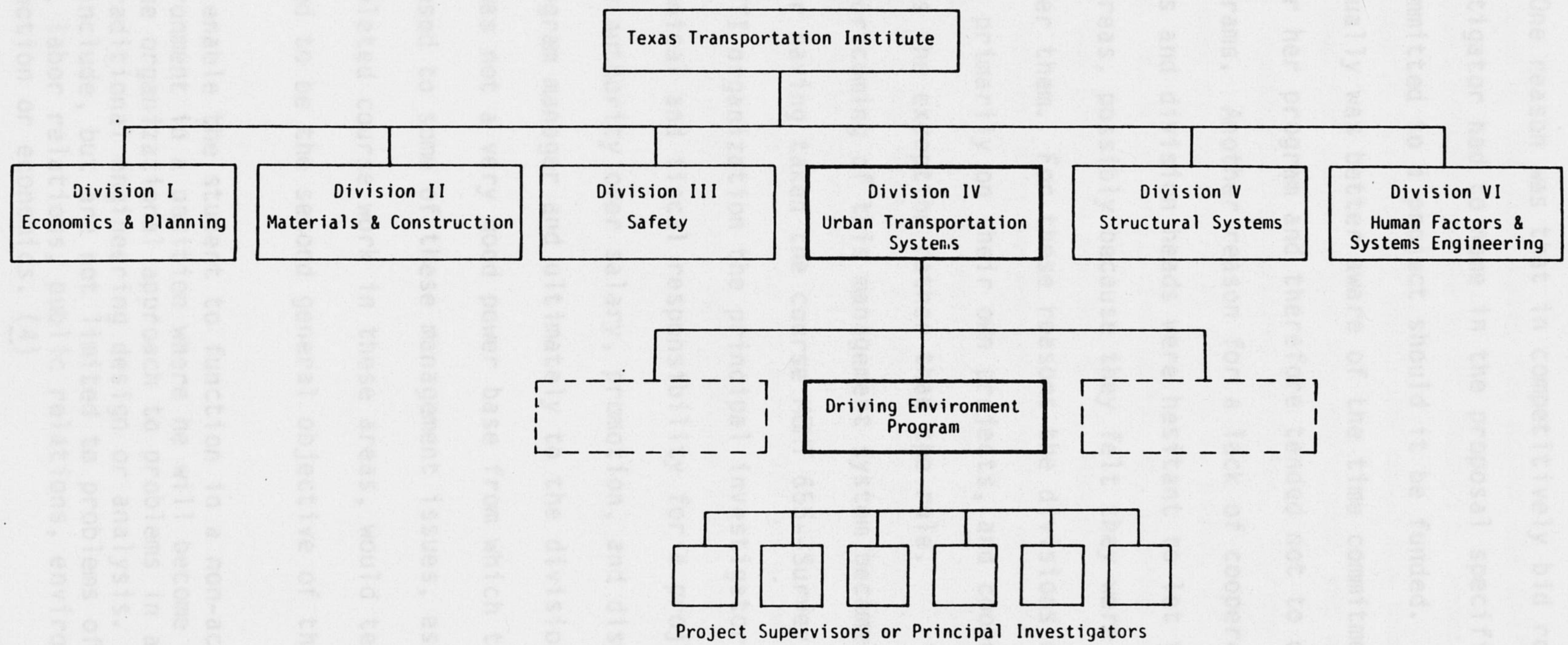
The program manager in turn was responsible for planning and staffing the program, preparing proposals and communicating with other Institute programs. The program manager assigned personnel to projects and, working with other program managers, recommended the assignment of personnel and personnel time to projects in his program.

The third level of management was the principal investigator, who was totally responsible for technical and fiscal management of a project and for appropriate management of personnel assigned to that project.

Staffing Philosophy

The program concept was implemented to allow for greater flexibility in assembling research teams from the various divisions and programs to work on multidisciplinary projects. In the author's

Figure 2. Texas Transportation Institute Organization Chart.



opinion, this concept of interdisciplinary participation never really materialized. One reason was that in competitively bid research a principal investigator had to name in the proposal specific individuals who would be committed to a project should it be funded. The principal investigator usually was better aware of the time commitments of the people in his or her program and therefore tended not to use people from other programs. Another reason for a lack of cooperation was that program managers and division heads were hesitant to let their people work in other areas, possibly because they felt they were relinquishing some control over them. For these reasons the divisions and even the programs worked primarily on their own projects, and cooperation with other groups was the exception rather than the rule.

Another shortcoming of this management system became apparent to the author after having taken the course MGMT 655--Survey of Management. In the TTI organization the principal investigator was charged with total technical and fiscal responsibility for a project, yet he had very little authority over salary, promotion, and dismissal except through the program manager and ultimately to the division head. Admittedly this was not a very good power base from which to operate.

Being exposed to some of these management issues, especially after having completed course work in these areas, would tend to fit what is supposed to be the second general objective of the internship:

> [T]o enable the student to function in a non-academic environment in a position where he will become aware of the organizational approach to problems in addition to traditional engineering design or analysis. These may include, but are not limited to problems of management, labor relations, public relations, environmental protection or economics. (4)

Key Personnel

While employed by the Institute, the author was assigned to the Driving Environment Program headed by Dr. Donald L. Woods. This program was contained in Division IV which was named the Design and Operations Division when the author began his employment and was later renamed the Urban Transportation Systems Division. During this time the division was headed successively by Dr. N. J. Rowan, Dr. Robert M. Olson and Mr. W. R. McCasland. Initially, Mr. Charles J. Keese was the Director of the Institute and Dr. C. V. Wootan was the Associate Director. Dr. Wootan later became the Director when Mr. Keese accepted the McDonald Chair of Transportation. Mr. Fred J. Benson was the Dean of Engineering and Director of the Texas Engineering Experiment Station. (Refer again to Figure 2).

The author left the Institute in July 1977 to accept an assistant professorship at his alma mater, North Dakota State University.

CHAPTER III

INTERNSHIP EXPERIENCE

While employed by the Texas Transportation Institute, the author was assigned to a variety of projects which were typical of the activities conducted by Division IV, Urban Transportation Systems. This Chapter discusses the contributions made to and experience gained from several of these projects. Appendix A contains a listing of the projects with which the author was associated.

Overview of Internship

The author was involved in a number of projects in the areas of transportation research and continuing education (Table 1). These projects were staffed with professionals from Division IV as well as support people and student workers from within the Institute. Most of these projects were of 12 to 18-month duration with overlapping deadlines; thus time commitments were usually split among two or possibly three projects. In addition, the author assisted in the preparation of several research proposals.

The scope of these projects ranged from some which involved less than one man-year's effort and only a few thousand dollars to one particularly large project for which the total contract price approached a million dollars. For this reason the author had varying amounts of responsibility ranging from activity in only one task or phase of a project to total involvement throughout the entire project.

Although the author was involved with some eleven major projects while employed by the Texas Transportation Institute, only four of

Table 1. TTI Project Assignments.

Assignment Type	Assignment Title
Traffic Engineering Related Research	• Corridor Analysis for Level of Service Design • Human Factors Requirements for Real-Time Motorist Information Displays • Effects of Design on Operational Performance of Signal Systems • Evaluation and Testing of Roadway Lighting Luminaires • Development and Evaluation of On-Freeway Traffic Control Systems and Surveillance Techniques • Highway Geometric Design Consistency Related to Driver Expectancy
Continuing Education for Transportation Engineering Officials	• Georgia State Highway Department Traffic Engineering Short Course • Alternatives for Improving Urban Transportation • Texas Governor's Office of Traffic Safety Traffic Engineering Short Course • Roadway Lighting Handbook • Safety Design and Operational Practices for Streets and Highways

these projects have been included in this chapter. This discussion attempts to illustrate how the general objectives of an internship were met even though the author was not formally participating in an internship at the time. The objectives of an internship according to the College of Engineering are:

1. To enable the student to demonstrate his ability to apply his knowledge and technical training by making an identifiable contribution in an area of practical concern to the organization or industry in which the internship is served; and

2. To enable the student to function in a non-academic environment in a position where he will become aware of the organizational approach to problems in addition to traditional engineering design or analysis. These may include, but are not limited to problems of management, labor relations, public relations, environmental protection or economics. (5)

The first three projects discussed below were related to highway traffic engineering research while the final project involved the preparation of a short course for transportation engineering professionals.

Effects of Design on Operational Performance of Signal Systems (6)

As the name implies, this study sponsored by the Texas Department of Highways and Public Transportation was conducted to determine how the traffic signal timing and geometric design of an intersection together affect the capacity of an intersection. Dr. Carroll J. Messer, Daniel B. Fambro and the author were the principal researchers on this project. A number of graduate students also participated in the field studies and data reduction activities. Traffic at a number of intersections in Houston, Austin and Bryan-College Station was observed and the existing signal timing and intersection geometry were noted. Ultimately a number of findings from this study were used to improve the Highway Department's PASSER-II traffic signal progression computer program. This computer program had been written previously by Messer and Fambro and has since been enhanced.

Author's Contribution to the Project

The author's primary activity in this study involved the determination of how many vehicles are able to turn left at an intersection which has no separate traffic signal phase for the left turn movement. In other words, the left turning drivers must observe the oncoming through traffic and judge whether the gaps in the traffic are of adequate duration to permit the left turn movement. A second opportunity for the left turn movement exists after the queue of opposing traffic has dissipated sometime during the green phase. If the entire green phase is used for opposing through traffic, the only left turns that will occur will be at the very end of the green phase, probably during the amber clearance interval.

To observe these phenomena, intersections selected by the research team and sponsor were video taped for later data reduction. Figure 3 shows the portable video camera system in use by members of the research team. The playback unit and monitor being used by the author in Figure 4 allowed for the measurement of various traffic flow parameters

Figure 3. Field Data Collection.

Figure 4. Field Data Collection

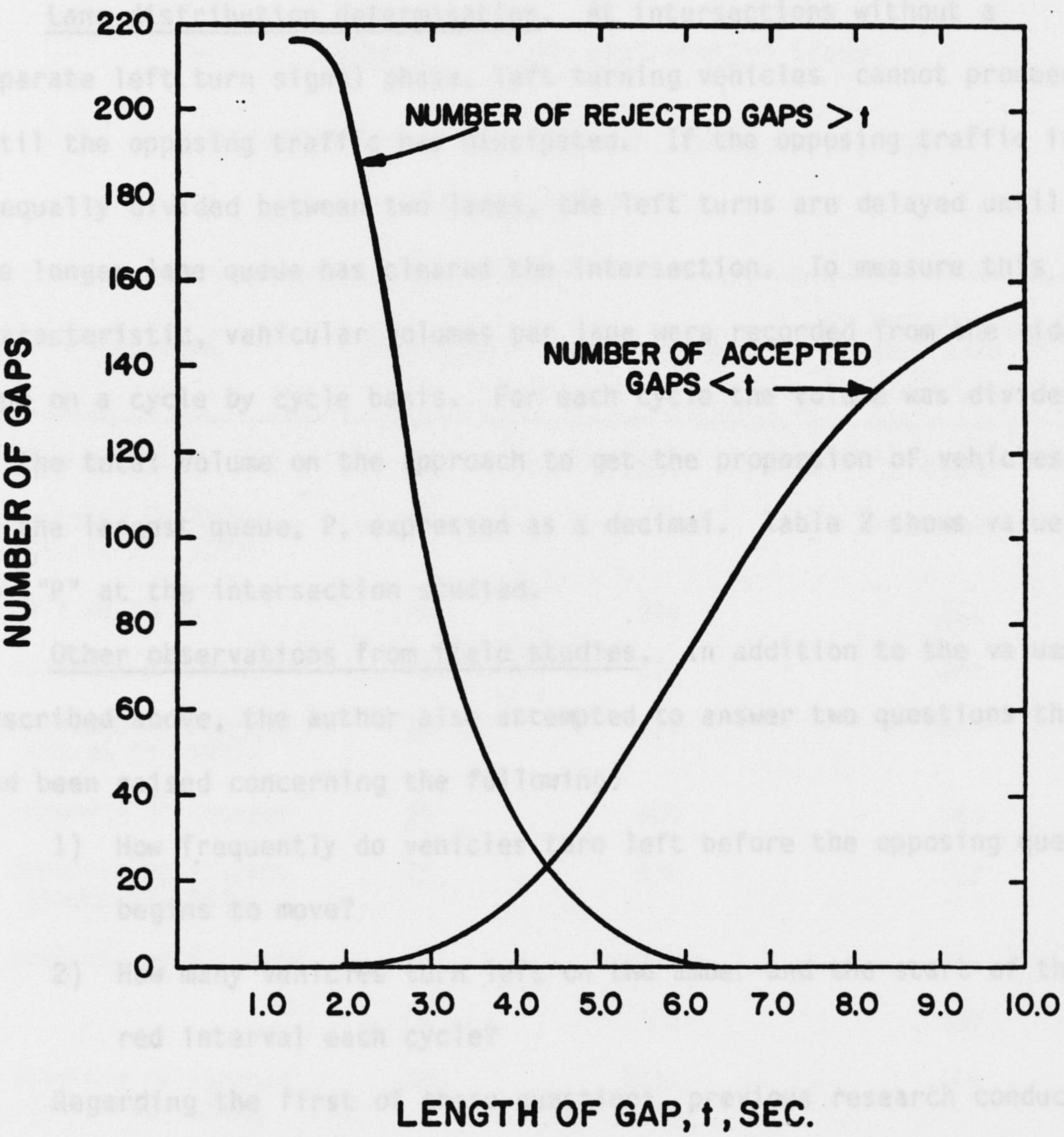
and the observation of individual drivers. This video tape method is preferable to real-time data collection methods because many more parameters can be evaluated and measurements can be repeated if missed the first time, a capability not possible when data are recorded manually in the field.

Based on these observations in the field and from the video tapes, the author reached the following conclusions regarding vehicles turning left at intersections controlled by a two-phase signal.

Critical gap determination. The gaps between opposing through vehicles at three intersections with left turn lanes were measured and the largest gap rejected and the smallest gap accepted for each left turning vehicle were recorded. These data were plotted and lines representing the cumulative totals for rejected and accepted gaps intersected at a value which approximated the critical gap. The critical gap is defined as one of sufficient duration such that there is equal probability that a driver would either accept a gap smaller than the critical gap or reject a gap larger than the critical gap. Figure 5 represents the combined data for the three intersections studied. Based on these data, a critical gap of 4.5 seconds was selected for use elsewhere in the intersection capacity calculation phase of this research effort.

Turning vehicle headway determination. When more than one vehicle turns left through a gap in the opposing traffic, the headway or time between vehicles ultimately affects the left turn capacity of an intersection. Headways were measured by the use of a stop-watch while observing the video tapes. For intersections without left turn lanes,

Figure 5. Results of Gap Acceptance Study.



PAIRS OF ACCEPTED AND REJECTED GAPS
FOR THREE INTERSECTIONS WITH
LEFT TURN LANES

the average turning headways were slightly greater than at intersections with a left turn lane. The results of this analysis indicated that headway values of 2.5 seconds for intersections with left turn lanes and 2.6 seconds for intersections without left turn lanes could be used in subsequent capacity calculations.

Lane distribution determination. At intersections without a separate left turn signal phase, left turning vehicles cannot proceed until the opposing traffic has dissipated. If the opposing traffic is unequally divided between two lanes, the left turns are delayed until the longer lane queue has cleared the intersection. To measure this characteristic, vehicular volumes per lane were recorded from the video tape on a cycle by cycle basis. For each cycle the volume was divided by the total volume on the approach to get the proportion of vehicles in the largest queue, P, expressed as a decimal. Table 2 shows values for "P" at the intersection studied.

Other observations from field studies. In addition to the values described above, the author also attempted to answer two questions that had been raised concerning the following:

1) How frequently do vehicles turn left before the opposing queue begins to move?
2) How many vehicles turn left on the amber and the start of the red interval each cycle?

Regarding the first of these questions, previous research conducted by others had indicated that if the driver at the head of the queue was a left turner there was a good chance that he would try to "jump the gun" by turning left before the opposing queue began to move. If

Table 2. Results of Lane Distribution Study.

AVERAGE PERCENTAGE OF VEHICLES IN HIGHER VOLUME LANE ON A CYCLE-BY-CYCLE BASIS

Location	Direction	Hourly Volume, Q	Percent in Higher Lane, P
SH 6 at SH 21	SB	312	.705
Montrose at Alabama (March 27, 1975)	NB	473	.594
SH 6 at SH 21	NB	506	.651
Hammerly at Gessner	WB	511	.608
Montrose at Alabama (March 27, 1975)	SB	529	.628
Hammerly at Gessner	EB	600	.614
Montrose at Alabama (March 15, 1975)	SB	820	.562
Montrose at Richmond	NB	925	.562
	SB	975	.559
Montrose at Alabama (March 15, 1975)	NB	1002	.543

this occurred fairly often it would add to the overall left turn capacity of an intersection. From the field studies, however, the author noted this movement occurred only 17 times out of 402 cycles when there was a left turning vehicle at the head of the queue. Based on this finding, the research team chose not to recommend any capacity adjustment for this maneuver.

The second question, how many vehicles turn left after the termination of the green interval, was addressed by viewing the video tapes and observing which signal indication was on when the driver turned left. The field studies indicated that when opposing traffic was light, most left turns were made through gaps in the opposing traffic. However, as opposing traffic became heavier, few if any left turns were possible through the opposing traffic. Under this condition the only left turns that could take place were those where the head left turner was actually waiting in the intersection and therefore completed the left turn after the green interval had ended and the opposing traffic had cleared the intersection. Sometimes even a second vehicle would turn, usually at the end of the amber or even at the beginning of the red portion of the cycle. Based on the field studies the author determined that 1.4 vehicles per cycle turned on the amber or red when a left turn lane was present and 1.03 vehicles per cycle turned when there was no left turn lane. Due to the limited number of observations in this study, the research team chose to use the value of 1.6 left turners per cycle as a minimum for subsequent capacity calculations. This value had been established previously by the State Department of Highways and Public Transportation for intersections where a left turn lane was provided. A minimum turning volume per cycle of 1.0 was selected where no left turn lane was used.

Although the author assisted in other phases of this research project, the activities listed above comprised the bulk of his efforts. The values determined by the author for the various parameters were later used by Messer and Fambro to formulate an improved intersection capacity model.

The findings of this study are summarized in TTI Report 203-2F, "A Study of the Effects of Design and Operational Performance of Signal Systems--Final Report." This project is described in Appendix A of this report.

Professional Experience Gained

For the most part the experience gained from this project was negative: that is, what not to do. Early on in the project the author was assigned the responsibility for video taping intersections and retrieving data from the video tapes. In the weeks that followed, considerable time was spent performing this rather mundane task. At the time, this effort seemed reasonable and it can be argued that high quality data collection is often the key to a successful project. However, this technician type of activity by a graduate engineer would seem to be a waste of talent. The author should have been more forceful in convincing his supervisor to provide an assistant who could have equally as well performed the data reduction. This would have allowed more time for activities on this and other projects which were more compatible with a skill level associated with engineering. An admitted shortcoming while employed by the Texas Transportation Institute was that on several occasions the author became comfortable in performing a certain task and in so doing, spent considerable time in activities which, although necessary to the project, could have been done by others. This ultimately led to some job dissatisfaction associated with performing tasks which were not professionally challenging.

Development and Evaluation of On-Freeway Traffic Control Systems and Surveillance Techniques (7)

This research effort consisted of several studies related to the control and surveillance of freeway traffic. The principal investigator for the project was William R. McCasland who at that time was stationed in Houston, Texas, as the head of TTI's Traffic Surveillance Center on the Gulf Freeway. The author was put in charge of one phase of this project which dealt with alternate designs for Closed Circuit Television (CCTV) Systems.

Author's Contribution to Project

When this study was conducted there were already a number of CCTV systems being used for bridge, tunnel, and freeway surveillance throughout Texas and the United States. The sponsor of this research, the Texas State Department of Highways and Public Transportation, was interested in two specific topics related to the use of CCTV:

1. The advantages of using improved television cameras, and;
2. Design alternatives for camera locations.

Therefore, the objective of this study was to explore these topics in both a laboratory and a field type setting.

Observations intended to meet the first objective were conducted by using a low light level television camera equipped with a pan and tilt accessory (Figure 6). The device shown in Figure 7 allowed for remote control of both the CCTV camera and the pan and tilt accessory.

Several features made the leased camera superior to CCTV cameras which had been used previously. One of these was an image intensifier which allowed the camera to produce a usable image under relatively low levels of illumination. To accomplish this, the leased camera used a silicon intensifier target vidicon tube which was purported to be over 500 times as sensitive to light as a standard camera. These cameras which are often referred to as low light level closed circuit TV (LLLCCTV) cameras were developed primarily for industrial surveillance and security. They operate quite well when subjected to light levels frequently found on urban freeways and arterial streets.

Other features of the leased camera included an automatic iris control which regulated the amount of light reaching the image tube and a peaking clipper which reduced the amount of "blooming" or washing out of a scene that contains an isolated intense light source. Lens options tested included the zoom function which allowed magnification of a particular scene and focal length extenders which increased the maximum viewing distance and ultimately the camera spacing.

The equipment was tested at three locations: the Texas A&M Research Annex, the North Central Expressway Surveillance Office in Dallas, and in Austin on a portion of the elevated section of

Figure 6. Closed Circuit Television Camera with Pan and Tilt Accessory.

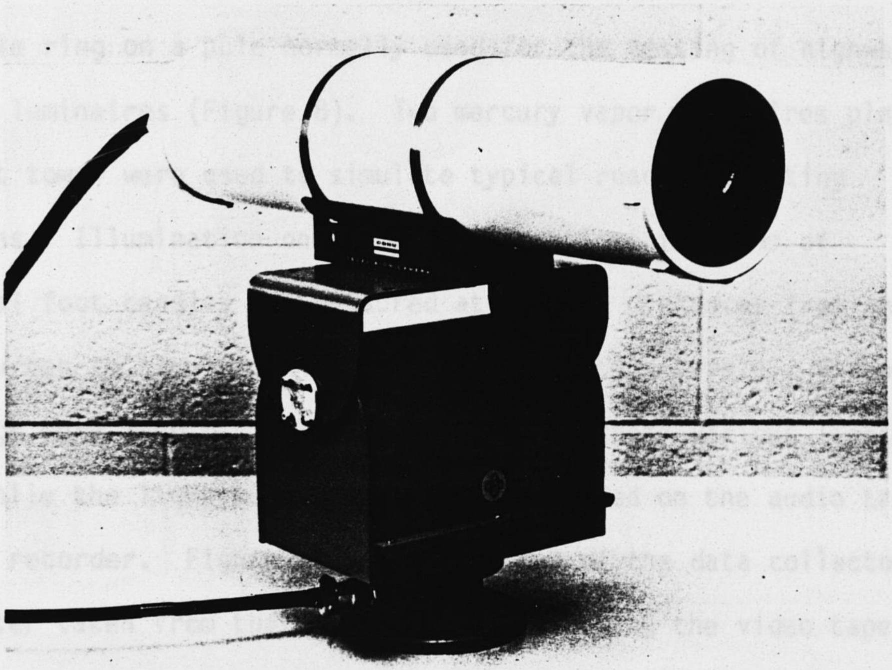
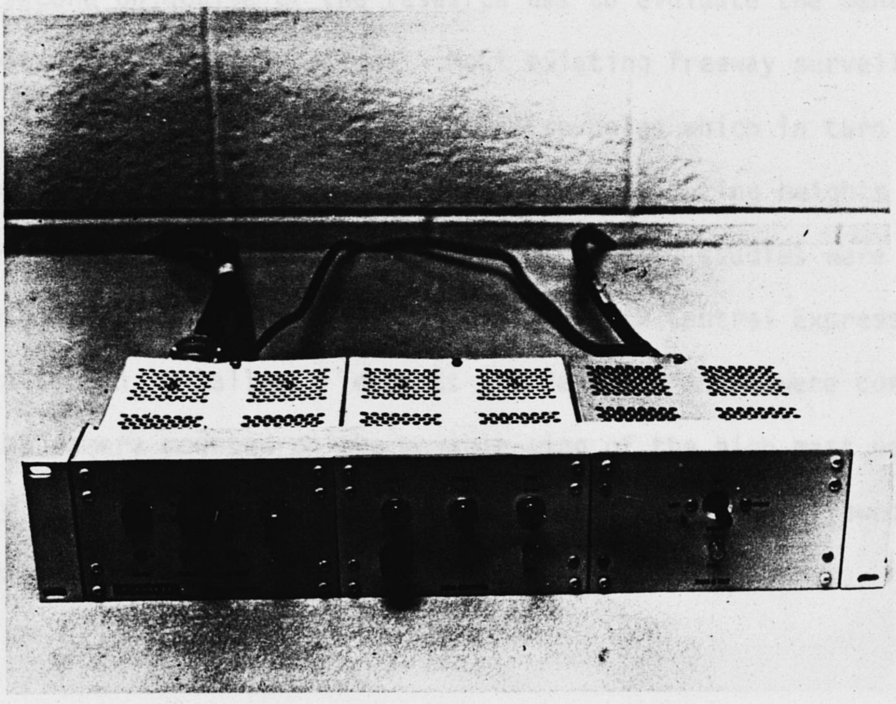


Figure 7. Remote Control Group for CCTV Camera and Pan and Tilt Accessory.



Interstate 35 which at that time was yet unopened to traffic. Tests at the Research Annex involved mounting the camera on a vertically adjustable ring on a pole normally used for the testing of highway lighting luminaires (Figure 8). Two mercury vapor luminaires placed on a 40-foot tower were used to simulate typical roadway lighting conditions. Illumination on the pavement surface in terms of horizontal foot candles was measured at various distances from the light sources to simulate high or low illumination levels. Video tape recordings were made of the image produced at these various light levels while the light meter reading was recorded on the audio track of the tape recorder. Figure 9 is a photograph of the data collector and light meter taken from the monitor while replaying the video tape of the test. The camera and accessories operated flawlessly and the research team was impressed with the quality of the video images produced under low light level conditions.

The second objective of the research was to evaluate the benefits of alternate CCTV camera locations. Most existing freeway surveillance systems utilize cameras attached to luminaire poles which in turn are located on overpass structures. This results in mounting heights of 40 to 50 feet. To evaluate increased mounting heights, studies were conducted both at the Research Annex and at the North Central Expressway CCTV installation in Dallas. Tests at the Research Annex were conducted with the camera mounted on the movable ring of the high mast pole originally used for luminaire testing. This configuration allowed the simulation of mounting heights up to 140 feet.

Figure 8. Camera with Pan and Tilt Accessory Mounted on Test Ring.

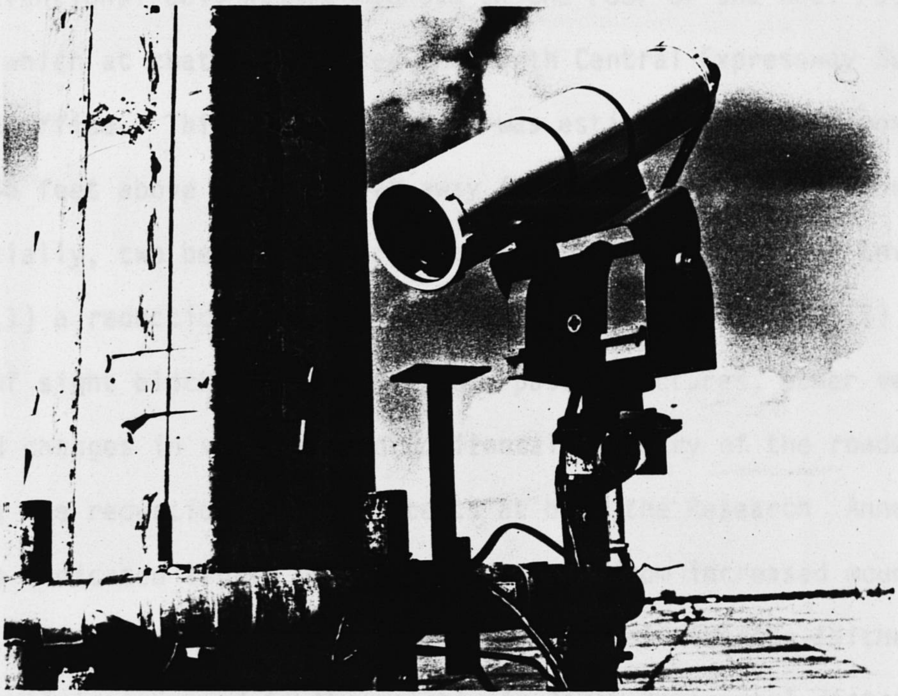
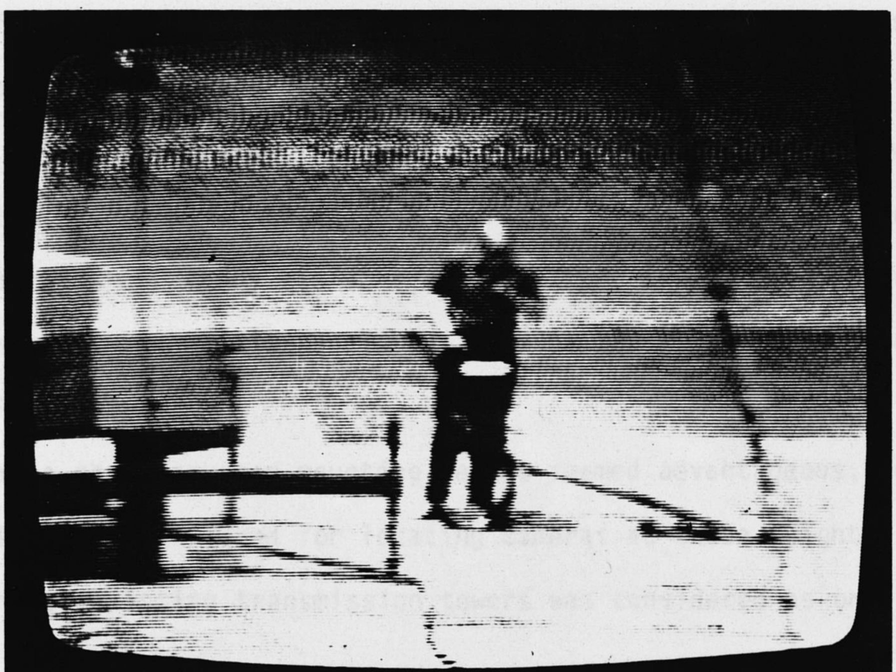


Figure 9. Night Scene of Data Collector Produced by Closed Circuit Television Camera.



In the Dallas studies the low light level camera was substituted for a conventional CCTV camera mounted on the roof of the Noel Page building which at that time housed the North Central Expressway Surveillance Office. This camera location was estimated to be approximately 145 feet above and 100 feet away from the freeway main lanes.

Initially, two benefits of increased mounting height were envisioned: (1) a reduction in glare from vehicle headlights, and (2) elimination of sight blockages caused by overpass structures, other vehicles, and changes in vertical and horizontal geometry of the roadway. Regarding the reduction of glare, tests at both the Research Annex and in Dallas indicated little benefit was derived from increased mounting heights. This is understandable when the vertical distance (either 40 or 140 feet) is compared to the relatively large horizontal distance (2500 feet). In either case the angle between the camera's field of view and a headlight beam is very small, causing considerable glare unless of course a newer style camera with a peaking clipper is used.

Sight blockages, on the other hand, decreased considerably with an increase in mounting height. Figure 10 illustrates a typical view from a luminaire pole top-mounted camera near the freeway. Many of the sight blockages caused by the vertical curvature of the roadway and by other vehicles were eliminated in the case of the roof-top mounted camera (Figure 11).

Because the increased mounting height seemed advantageous, several alternatives were explored for locating cameras at these heights. Attachment to existing transmission towers was considered as one

Figure 10. View from Camera at 50-foot Mounting Height.

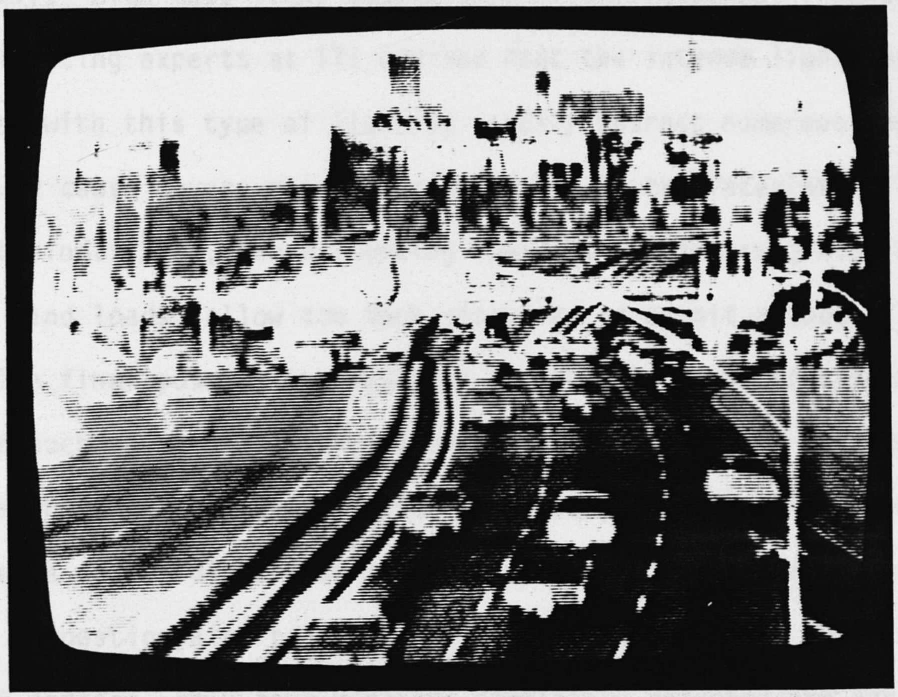
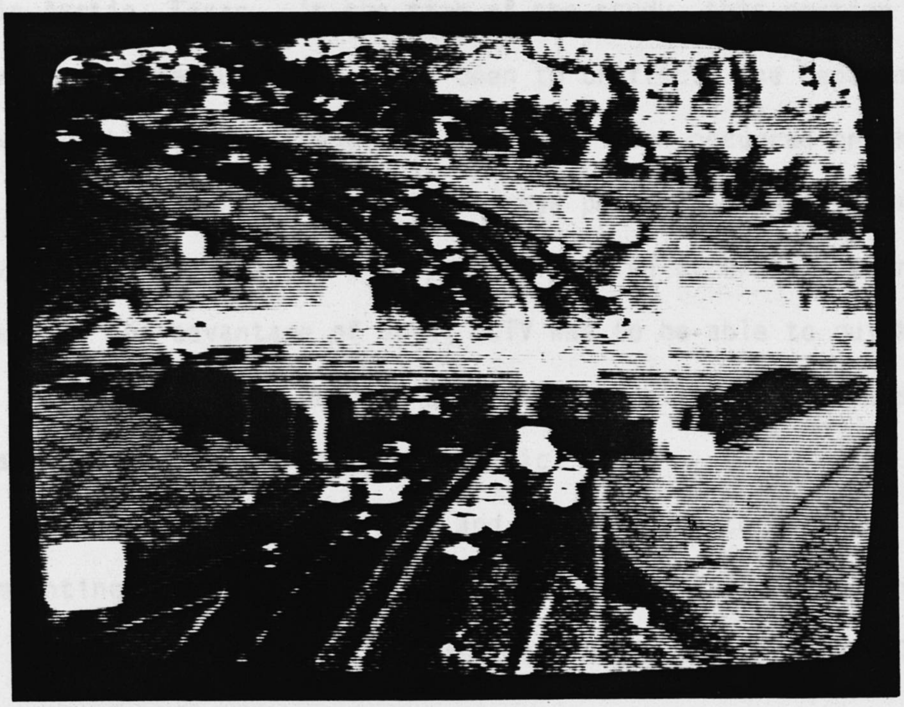


Figure 11. View from Camera at 145-foot Mounting Height.



possibility. However these structures may not always be present near the freeway. High mast light towers were also considered. However, roadway lighting experts at TTI advised that the intense light levels associated with this type of lighting usually attract numerous insects which could cause severe maintenance problems on the faceplate of the camera housing. Also, these lighting towers may, when subjected to moderate wind loads, allow too much vibration to permit a good CCTV image. The final possibility explored was the placement of cameras on roof tops such as at the TTI research facility in Dallas. In order to determine whether the private sector would permit the installation of CCTV cameras on buildings near the freeway, the author drafted and distributed a questionnaire to 31 high rise building managers in Houston. Of the 18 replies, only four managers completely rejected the idea of such an installation.

The third test site for the leased camera was the elevated portion of I-35 in Austin, Texas. At the time of the study, this section of freeway was complete but was not yet open to traffic. The Department's concern was that if an incident such as a collision occurred on this elevated section with no intermediate access points, emergency vehicles would have to proceed against the normal direction of traffic to reach the blockage. The advantage of using CCTV was to be able to quickly identify the nature of the problem once some other system had sensed a significant slowdown or blockage of traffic.

The camera was placed in a boom and bucket truck to simulate various mounting locations relative to the freeway lanes. The remote controls for zoom, focus, and tilt simulated those controls usually provided in a permanent freeway surveillance facility. Video tape recordings of the image produced at various mounting configurations were made for future reference.

In summary, one conclusion of this study was that the low light level capability of the leased camera made it far superior to conventional CCTV cameras during non-daylight hours when only typical street lighting was available. Also, increased camera mounting heights such as that provided by roof-top locations eliminated a number of sight obstructions usually associated with cameras mounted on conventional street lighting poles.

Professional Experience Gained

A greater sense of accomplishment was derived from this project than any other activity at TTI due primarily to employee motivation and commitment. Herzberg, in a discussion of employee motivation (8), distinguishes between motivational and maintenance factors. Motivational factors he says, include achievement, recognition, the job itself, responsibility and advancement. Maintenance factors, on the other hand, include company policy and administration, supervision, salary and working conditions. Herzberg concludes that a high level of organizational performance in the maintenance area does not necessarily result in a high level of satisfaction and positive feelings. However, a low level of organizational concern about these factors results in dissatisfaction. Therefore only the motivational factors, such as those gained from the sense of doing a good job and being appreciated, lead to job satisfaction and commitment to the organization. The author interprets Herzberg's theory as saying that it is possible to pay an employee enough to perform a task he doesn't like, but the positive effects will be minimal.

This project dealing with closed circuit television freeway surveillance provided a genuine sense of accomplishment due primarily to the author's responsibility for one task all the way from the literature search to the final report. This involved not only the utilization of technical knowledge, but also required communicating with the technicians who built some of the hardware, supervising student workers and accounting for funds expended on the project. The principal investigator was available for consultation but allowed the author considerable latitude in guiding this task of the reseach project.

This experience with the Texas Transportation Institute as well as other organizations has lead to a modification of the author's own management techniques. For example, in the pavement research effort discussed in Appendix C, certain tasks were delegated to a graduate student assistant for which the student was asked to formulate a course of action and then follow through with the required work. This method seemed to work quite well, because the student knew why he was performing specific activities and he was aware of how each activity led to the eventual completion of the project.

Human Factors Requirements for Real-Time Motorist Information Displays (9)

One reason for selecting this assignment for a more detailed explanation is its relative size and complexity when compared, for example, with the closed circuit television camera project discussed above. In the television study, the author was almost solely in charge of one portion of the project while in the study discussed below, a number of people were involved with each task.

In 1974 one of the largest contracts ever acquired by TTI was awarded to study the human factors requirements for real time information displays. As the name implies, this included traffic information devices capable of presenting messages that could be changed quickly to respond to traffic conditions such as an accident blocking freeway lanes or a special event such as a sports event which overtaxes a certain route to the sports facility. The project included such topics as driver information requirements for intercity and intracity trips, traffic state descriptor variables, point diversion for special events, visual information systems, and audio visual systems.

Dr. Conrad L. Dudek of TTI's Urban Transportation Systems Division was the Principal Investigator while Dr. R. Dale Huchingson of the Human Factors Division served as the Co-Principal Investigator. The author participated in several of the project tasks as described below.

Author's Contribution to the Project

Fairly early in the project the author conducted driver interviews at Interstate highway rest areas near Houston and Dallas, Texas. This involved asking a number of questions regarding the driver's origin and destination, trip purpose, driving habits, and most important, the driver's anticipated information needs for driving while in the nearby large city. Admittedly this activity required very little engineering aptitude but was one of those jobs associated with every project which someone had to do.

Later in the project, a series of laboratory studies was designed and administered to measure a number of variables related to changeable message signs. These included message length or the number of words that a driver can read and comprehend as well as message display time as related to the time required to read a message. Many of these tests were conducted by filming a particular message or a series of words comprising a message and then controlling the viewing time by editing the film which was ultimately viewed by subjects in the laboratory.

One specific study investigated the use of a bulb matrix sign similar to those used by banks and other institutions for displaying the time and temperature as well as advertising and public service messages. The author's first activity involved learning to run a prototype, portable version of this type of sign which had been manufactured by an electronics firm in Fort Worth, Texas. The sign was trailer-mounted and was composed of a 7 x 60 array of 25-watt bulbs, 1.5 feet high and 12 feet long. Because most characters were five bulbs wide, any message or symbol not exceeding about ten characters could be displayed. Messages placed on the portable sign were subsequently photographed and the edited film was shown to subjects in the mediamaster laboratory on the Texas A&M University campus. An example of these studies, in the case used to determine the optimal method of presenting a four word message, is illustrated in Figure 12. The code S-4-2-2 indicates a sequential display, four words per message, two words per exposure, and two words per line. Messages with the same words but varying configurations were shown at varying display rates and the percent correct responses by test subjects was recorded. Considerable testing of this type was done to determine the most effective values for variables such as display times, message length, and number of lines.

One interesting portion of this research dealt with an evaluation of the effect of lamp matrix bulb loss. In this study the portable sign was filmed inside a darkened building so that only the energized bulbs would show and any distracting background scenes would be eliminated. A selected list of words were displayed individually on the sign and filmed under varying levels of bulb "failures." Bulb failures were predicted through the use of a random number table and then created by unscrewing the required number of bulbs to simulate bulb losses of 10, 20, 30, 40, and 50 percent. Laboratory test subjects were shown 35-mm slides of the words taken during various degrees of simulated bulb failure and the study results were analyzed (Figure 13).

Of all the studies related to the physical requirements of bulb matrix signs, the author had the most responsibility for one study dealing with symbol recognition. This subject was deemed important because in the diversion of a driver from his primary route to and along an alternate route, the unfamiliar driver must be provided with

Figure 12. Four-Word Sequential Signs.

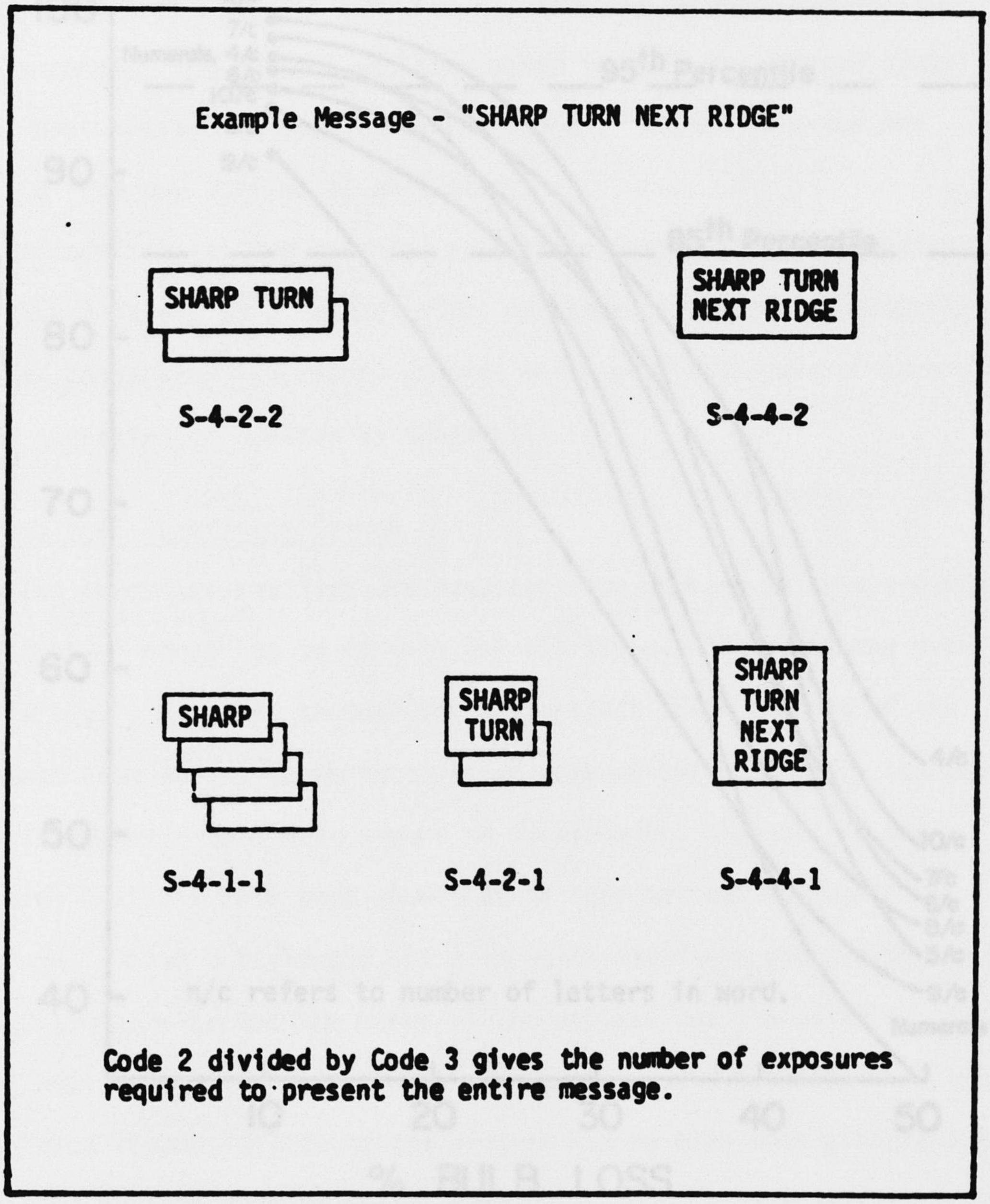
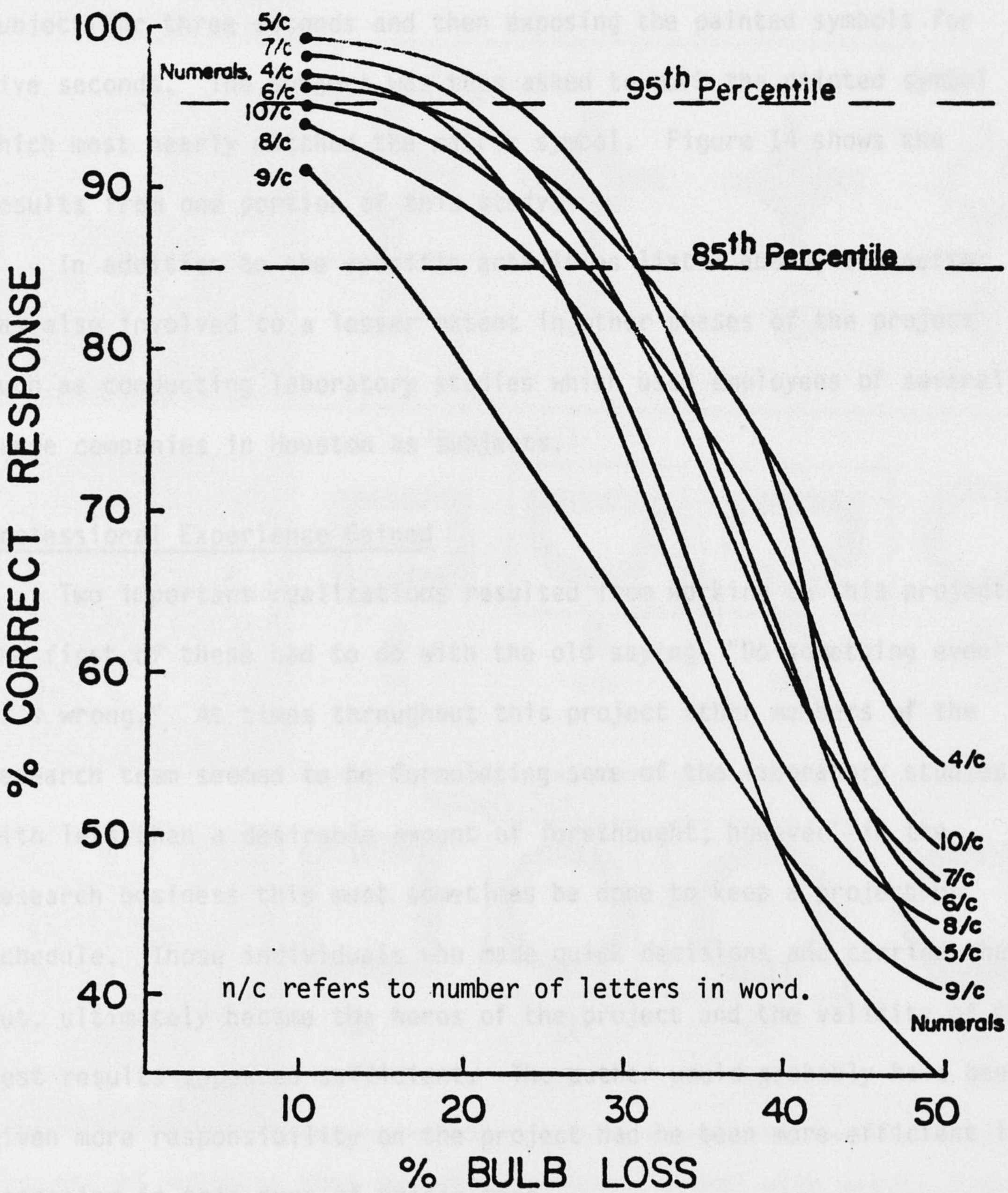


Figure 13. Results of Bulb Loss Study.



some form of trailblazer. If a symbol is used as a trailblazer, the symbol painted on signs along the route must be identifiable with the symbol formed on the bulb matrix sign. This is complicated by limitations of the matrix sign in only being able to form certain shapes.

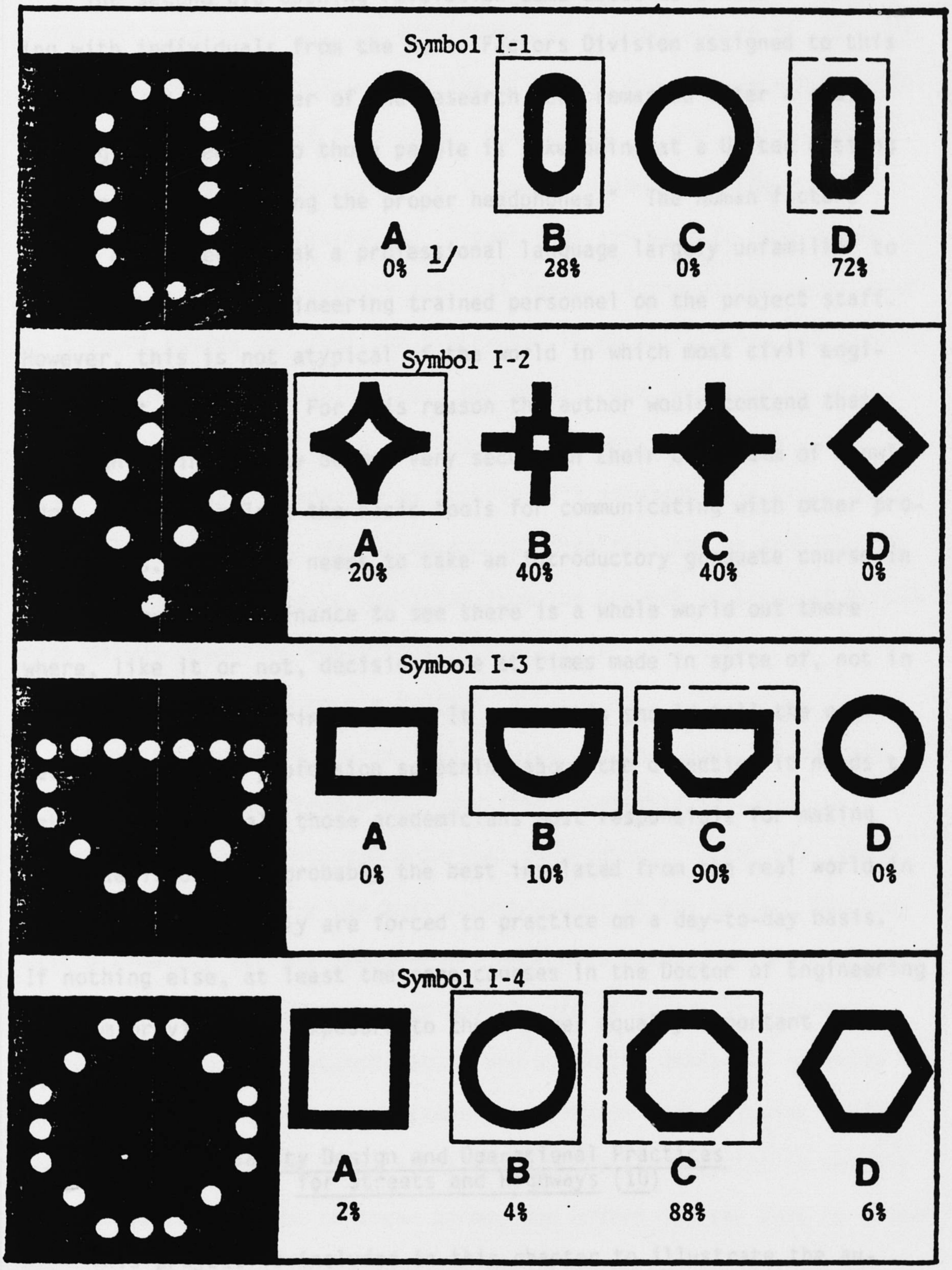
The study was conducted by first exposing a matrix symbol to a subject for three seconds and then exposing the painted symbols for five seconds. The subject was then asked to mark the painted symbol which most nearly matched the matrix symbol. Figure 14 shows the results from one portion of this study.

In addition to the specific activities listed above, the author was also involved to a lesser extent in other phases of the project such as conducting laboratory studies which used employees of several large companies in Houston as subjects.

Professional Experience Gained

Two important realizations resulted from working on this project. The first of these had to do with the old saying, "Do something even if it's wrong." At times throughout this project other members of the research team seemed to be formulating some of the laboratory studies with less than a desirable amount of forethought; however, in the research business this must sometimes be done to keep a project on schedule. Those individuals who made quick decisions and carried them out, ultimately became the heros of the project and the validity of the test results appeared sufficient. The author would probably have been given more responsibility on the project had he been more efficient in operating in this type of crisis mode.

Figure 14. Symbol Selection Results.



1/ Percent of subjects that associated painted symbol with matrix symbol.

The second eye opening revelation came about as a result of working with individuals from the Human Factors Division assigned to this project. As one member of the research team remarked after a staff meeting, "Listening to those people is like being at a United Nations session without wearing the proper headphones." The human factors people did indeed speak a professional language largely unfamiliar to many of the civil engineering trained personnel on the project staff. However, this is not atypical of the world in which most civil engineers must practice. For this reason the author would contend that although engineers may become very secure in their own realm of knowledge, they often lack the basic tools for communicating with other professionals. One only needs to take an introductory graduate course in law, management or finance to see there is a whole world out there where, like it or not, decisions are at times made in spite of, not in response to, engineering input. It seems this should tell the engineering education profession something about the direction it needs to take. Unfortunately those academicians most responsible for making these decisions are probably the best insulated from the real world in which they only rarely are forced to practice on a day-to-day basis. If nothing else, at least the core courses in the Doctor of Engineering program provide some exposure to these other equally important bodies of knowledge.

Safety Design and Operational Practices for Streets and Highways (10)

This project is included in this chapter to illustrate the author's experience in the area of continuing education for engineers.

In contrast to a research project which involves the discovery of new ideas and relationships, the development of a short course of the type described herein is critical for the efficient and concise presentation of a particular body of knowledge. The content of the course must be tailored to a particular audience in such a manner that the course objectives are met effectively. Visual aids are usually also needed to reinforce and further clarify critical ideas. Although the participant in a short course may feel the instructor is merely talking and showing a few slides, considerable effort has usually been expended by the developers of the course in writing student notes, preparing visual aids, and possibly preparing an instructor's notebook. In the discussion below, the author has attempted to illustrate how he contributed to the project and how he benefited from the project in terms of knowledge gained regarding educational activities of this kind.

Author's Contribution to the Project

As with any short course dealing with a rather specific subject and state-of-the-art technology, the final responsibility for the course content lies with the principal instructors. After all, these individuals are usually the most knowledgeable in the subject and they must ultimately satisfy the sponsor. For this reason, the role played by junior writers of a course is usually one of doing literature searches, assembling subject matter and supplying drafts of selected sessions of the course. Any resemblance between what a junior staff member submits and the final notes for a particular session is usually coincidental. Couched in these terms, the author can say that he wrote Sessions 3-5 and 4-5 of this course (Table 3).

Table 3. Safety Design and Operational Practices Course Agenda.

Session	Topic	Title
1	1	Introduction
2	1	Model Safety Improvement Programs
3	1	Driving Expectancy in Safety Design
3	2	Design Consistency
3	3	Horizontal Alignment
3	4	Vertical Alignment
3	5	Cross Section: Roadway Elements
3	6	Cross Section: Roadside Elements
3	7	Cross Section: Narrow Bridge Treatments
3	8	Intersection Design
3	9	Safety and Operational Requirements for Interchanges
4	1	Safety in Planning
4	2	Safety Considerations in Urban Transportation
4	3	Designing a Safe Driving Environment
4	4	Roadway Lighting Systems
4	5	Railroad Grade Crossing Safety
4	6	Safety Design in Maintenance and Construction Operations
4	7	Signing and Delineation
5	1	Traffic Barriers
5	2	Crash Attenuation Systems
6	1	Legal Responsibility of Public Officials for Highway Safety

Considerable time was also spent packaging the course materials into their final form. These items included the participant notebook, visual aids and the instructor's notebook. A sample page of the course notes is shown in Figure 15 to illustrate the two column format achieved by photographically reducing the conventional size typing prior to printing. This greatly reduced the volume of paper while at the same time preserved the readibility. (It should be noted that the notes were originally printed on 8 1/2 x 11 paper, however, Figure 15 was further reduced for inclusion in this internship report). A technical writer, and several student workers assisted in the layout and editing of these notes.

This course also required the gathering of approximately one thousand 35-mm slides. While a number of these were adapted from other sources, many were either figures that had to be drafted or word slides made by using a lettering machine. The originals were then photographed using a reversal process to provide white lines and letters on a colored background. In this phase the author was responsible for seeing that the draft of each slide as suggested by the session writer was eventually finalized and photographed.

Professional Experience Gained

As a result of this project, an appreciation was gained for what really goes into the preparation of a course of this scope. The ability to effectively assemble the course notes and visual aids required to present a particular block of information was enhanced by participation in this project. This experience was later reinforced by the course

Figure 15. Example of Notes for Safety Design and Operational Practices Course.

TOPIC 3 SESSION 4

VERTICAL ALIGNMENT

<u>Objectives</u>:

1. *To review the background and development of allowable grades for vertical alignment design.*
2. *To explore the methodology of designing truck climbing and auxiliary passing lanes.*
3. *To review the application of sight distance criteria to vertical curve design.*

3.4.1 INTRODUCTION

To identify a general objective of vertical alignment design, it seems entirely appropriate to quote the new Red Book, <u>A Policy On Design of Urban Highways and Arterial Streets</u> (<u>1</u>). It is stated very succinctly that "highways should be designed to encourage (and permit) uniform operation throughout." This could be stated as a general objective for the entire design process, but it seems most appropriate for vertical alignment design.

3.4.11 Scope

There are three specific areas of vertical alignment that we will explore in greater detail. These are:

- Control of Grades - The steepness and length of grades
- Vertical Curves - Joining grades
- Sight Distance Alternatives

It is not the intent in this session to delve into vertical alignment in its most minute detail. Since time is limited, we will concentrate on some historical background of design controls so we may better understand the standards available to us today. Further, we will examine some new concepts of vertical alignment design. For example, viewing time and anticipatory sight distance may be more meaningful than stopping sight distance.

3.4.12 Background and Evolution of Design Controls

The general objective stated above is entirely appropriate for the present day mode of operation on our streets and highways, and it was a good general objective for the engineers of highways and roadways during the pre-automobile era. In fact, our predecessors in highway engineering were far more concerned with vertical alignment than we are today.

<u>Grades</u>. During the era of horse-drawn wagons there was a very critical concern for grades because the steeper the grade, the more horses were required for pulling a given load and, consequently, higher operating costs were experienced. Figure 3.4.1 illustrates the grade effects on number of horses and the relative costs taken from <u>Wiley's Highway Text</u> published in 1928 (<u>2</u>). It is easy to realize even today that grades were most important particularly when the maximum speed was something on the order of eight mph (13 km/h). At such speeds, horizontal alignment was of little concern and, therefore, the road could be built as indirect as necessary to achieve relatively flat grades.

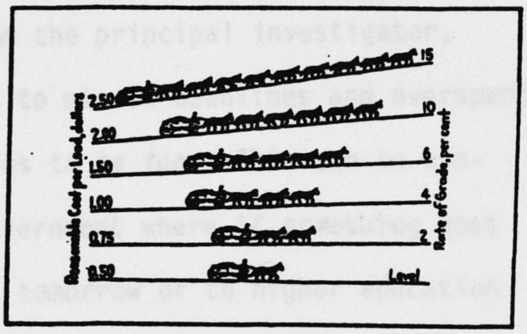


Figure 3.4.1 Effect of Grades on Hauling Power *(Source: Wiley)*

The average grade resistance (<u>2</u>) was computed as

$$R_R = 20g$$

where: R_R = rolling resistance per ton of load

g = the grade in percent

For example, a 4-ton (3600 kg) freight wagon would offer a resistance of 400 pounds (182 kg) when being pulled up a grade of 5%. Early design guides pointed out that one horse typically could pull one-tenth his weight under sustained loading. In other words, it would require four, 1000-pound

Rev: 7/77

ET 604 -- Industrial Communications and Training Systems. This work experience and college course should help the author to better communicate technical information throughout his career.

Summary of Work Experience at TTI

By the time the author had completed this report, he had already held positions in three sectors of civil engineering: state government with the Nebraska Department of Roads, higher education at North Dakota State University, and research with TTI. The author's varied experiences in the civil engineering field allowed for an objective evaluation of the work experience at TTI. The following observations are offered in this context.

Research, especially when conducted on a full-time basis without accompanying teaching duties, can become a fairly stressful situation. Unless there is strong leadership from the principal investigator, normal human procrastination can lead to missed deadlines and overspent budgets. At this point research ceases to be fun. This can be contrasted to the philosophy of state government where if something does not get done one day, there is always tomorrow or to higher education where a 15-week calendar dictates the end of the semester.

Associated with the delay in completing certain research projects is Parkinson's Law which says that work expands to fill the time available. In a number of cases, the author would have benefited from performing a particular duty on a research project and then moving on to something else rather than spending an inordinate amount of time with little to show for it.

Probably the primary conclusion reached from the TTI work experience is that a person has to enjoy his work to be happy. Toward the end of his employment at TTI, the author began to feel that he was not making a total contribution to the organization and this led to his decision to leave.

On the other hand, the technical proficiency gained from working with the professional staff at TTI would be very difficult to replicate at any other institution. The author's basic knowledge of highway lighting, roadway design, roadside safety, and intersection operation was greatly enhanced as a result of working on the various short courses and research projects conducted by TTI. This knowledge has already proven invaluable in the education field since leaving TTI. Considerable insight into the operation of a reseach project was also gained and subsequently put to use while at North Dakota State University.

CHAPTER IV

APPLICABILITY OF THE DOCTOR OF ENGINEERING PROGRAM

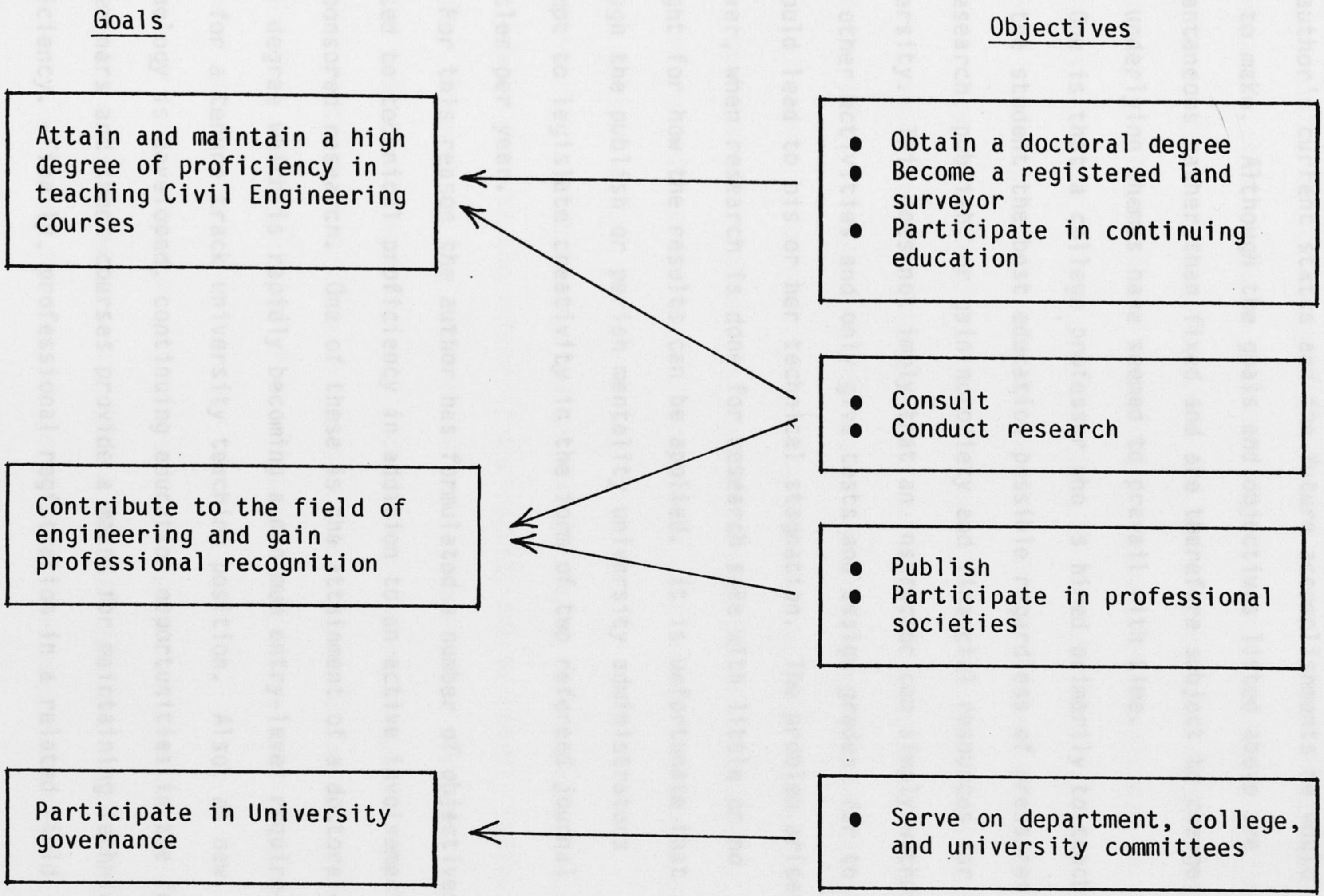
When this report was written, the author had already experienced several employment areas within the field of transportation engineering and, after having enjoyed teaching for three years in a university atmosphere, was preparing for a career in higher education. Because this career decision was made before returning to Texas A&M University to complete the bulk of the Doctor of Engineering requirements, much of the program of study was tailored to fit these career goals. This chapter is intended to: (1) explain the author's goals and objectives and (2) illustrate specific examples of how the Doctor of Engineering should help in realizing their attainment.

Career Goals and Objectives

Over the past few years the author has formulated a number of goals and objectives which should lend themselves to the enhancement of his professional career (Figure 16). Although these goals and objectives are discussed below in terms of the author's anticipated return to North Dakota State University, they would be equally applicable to other institutions of higher education.

The formulation of these career goals has been influenced by a number of acquaintances in the engineering and education communities as well as by the author's own personal beliefs. A social conversation

Figure 16. Career Goals and Objectives.



with a peer, criticism by a supervisor or encouragement by an instructor have all at sometime contributed to a particular mind set regarding the author's current status and the future accomplishments he would like to make. Although the goals and objectives listed above are instantaneous rather than fixed and are therefore subject to change, some underlying themes have seemed to prevail with time.

One is that a college professor who is hired primarily to teach owes the student the best education possible regardless of pressures to do research, publish, or gain notoriety and financial resources for the university. This does not imply that an instructor can simply withdraw from other activities and only give tests and assign grades, for to do so would lead to his or her technical stagnation. The problem arises, however, when research is done for research sake with little or no thought for how the results can be applied. It is unfortunate that through the publish or perish mentality university administrators attempt to legislate creativity in the form of two refereed journal articles per year.

For this reason the author has formulated a number of objectives related to technical proficiency in addition to an active involvement in sponsored research. One of these is the attainment of a doctoral-level degree which is rapidly becoming a minimum entry-level requirement for a tenure track university teaching position. Also, as new technology is developed, continuing education opportunities in the form of seminars and short courses provide a means for maintaining technical proficiency. Finally, professional registration in a related field such as surveying should be another indication of an individual's efforts to gain technical competence in that field.

Consulting by college professors is a common means of supplementing what are often mediocre salaries when evaluated according to industry-wide standards. However, it is the author's contention that the university professor should not unfairly compete with engineers in the private sector who rely on the same type of work for their primary means of employment. Instead the college instructor should be the "consultant's consultant" performing those tasks that the consultant may not have either the time or expertise to undertake. Expert witness testimony often proves both financially and professionally profitable to the university professor who is usually considered desirable due to his or her academic credentials and status as a disinterested party. The author would hope to become involved in both consulting and expert witness activities.

Research, although required to some extent at most universities, appeals much more to the author if the results can be readily implemented. Too much of the research in the transportation area, for example, is sold by the man-hour and evaluated by the report-pound. Research reports which are merely approved, cataloged and shelved serve only to fuel the skepticism of the taxpayer or consumer, the ultimate research sponsor.

As with research, the publishing of research findings and position papers should not be an end unto themselves, but rather a reflection of the writer's grasp of the subject and his ability to present ideas.

Publishing is also important because it adds to the university's and individual's credentials which in turn helps to attract students especially at the graduate level.

Participation in professional societies is another means of gaining professional recognition and is therefore one of the author's objectives. Professional and technical societies make considerable contributions to the engineering field as well as the general public in terms of design and safety standards.

A final objective is to become involved in all levels of university governance. Many opportunities exist at most universities to influence the direction and role of the institution at each of the department, college and university-wide levels. In these times of escalating state and federal intervention in university affairs, the faculty must not be afraid to be heard on matters affecting their own destiny as well as the future of the institution.

<u>Anticipated Benefits of the Doctor of Engineering</u>

Undoubtedly the attainment of any college degree is an indication of an individual's initiative and brings with it a certain degree of academic maturation. However, a number of examples can be shown where courses completed as part of the Doctor of Engineering program are readily applicable to the author's career objectives. The following courses completed at Texas A&M University relate directly to the field of transportation engineering in which the author will be teaching:

CE 489 -- Railroad Engineering

CE 615 -- Flexible Pavement Design

CE 624 -- Environmental Effects of Transportation Systems

CE 625 -- Geometric Highway Design

CE 626 -- Roadside Safety Design

CE 636 -- City Street Design

CE 672 -- Urban Transportation Study

CE 685 -- Problems (Rigid Pavement Design)

IEn 634 - Man-Machine Systems

The above courses plus the author's work toward a Master of Engineering at the Pennsylvania State University should provide a broad information base for future teaching in the field of transportation engineering.

The author's second academic interest is that of land surveying and because of this he completed the following courses while at Texas A&M:

CE 469 -- Advanced Surveying

CE 661 -- Photo Interpretation

CE 685 -- Problems (Photogrammetry)

These courses should not only enhance the author's teaching ability in this area but should also help to realize the objective of becoming a registered land surveyor.

In addition to the application toward the goal of teaching proficiency, those engineering courses should also help to meet the objectives regarding consulting and research. For example, as a result of the flexible pavement design course, the author has already envisioned several areas in which his past research work for the North Dakota Highway Department in the area of pavement performance could be continued and expanded.

The Doctor of Engineering core courses along with two additional Education Administration courses lend themselves most directly to the objective of participation in professional societies and serving on university committees. Mgmt 655 -- Survey of Management proved most beneficial to the author in recognizing various management situations that actually do occur. More specifically related to the university environment, Ed Ad 655 -- Administration of Higher Education provided considerable insight into the issues currently faced by college administrators and the problems of governing departments which are at best "loose confederations of individuals held together by red tape." (11) The Ed Ad 685 -- Problems course allowed the author to explore in more detail possibilities for improving the non-technical courses in an engineerng curriculum, a current topic of concern for many engineering educators.

Acct 640 -- Accounting Concepts and Procedures I and Mgmt 643 -- Legal Relationships have given the author deeper insight into financial and legal transactions which occur in the business world. Whether attempting to understand the computer accounting form for a research project or serving as the treasurer for a professional society, the information from these courses regarding items such as balance sheets, contracts, and negotiable instruments should prove to be valuable.

Fin 635 and 636 -- Financial Management for Engineer I and II, although providing good background information, tend to apply more to the private sector with which the author has had relatively little contact.

E. T. 604 -- Industrial Communication and Training Systems should serve to help the author meet several of his career objectives. The formulation, organization and presentation of technical information is important in each of the areas of teaching, research, consulting and participating in group decision making.

Finally, the issues raised in ItdE 671 -- Professional Ethics and Practice helped the author in establishing his career goals and objectives and to reinforce his beliefs regarding the ethical and professional responsibilities of the engineer. This course will undoubtedly affect the author's future actions regarding such topics as pricing of engineering services, competitive bidding for engineering services, and unionization of engineering faculty.

In this chapter the author has attempted to show that in addition to minimum degree requirements, the courses he completed at Texas A&M were for the most part readily applicable to his immediate goals and objectives. It is hoped that it provides at least some encouragement for others who may wish to investigate the Doctor of Engineering program as a preparation for a career in higher education. Although the Doctor of Engineering program does not contain the research emphasis of the Ph.D. program, it does lend itself more toward the professional aspects of engineering practice which are equally important in the education of undergraduates.

CHAPTER V
SUMMARY

This report described the author's professional engineering experience while a member of the Texas Transportation Institute at Texas A&M University from March 1974 through July 1977. A report of this type is normally written to show that the Doctor of Engineering candidate has met his or her internship objectives. In this instance, however, this report was written and twelve additional hours of academic course work were completed in lieu of the internship, an option permitted in certain cases by the College of Engineering. This request to have the internship waived was related to the anticipated marginal benefit of another year's work experience during the internship and the advantage of being able to take the additional hours of course work.

The Texas Transportation Institute was founded in 1957 to address increasingly complex transportation research needs. Since that time the Institute had dealt with the planning, design, construction, operation, maintenance, enforcement, safety, economics, ecological, and social aspects of the various modes of transportation. The Institute is a part of the Texas A&M University System.

While at the Institute, the author was assigned to Division IV - Urban Transportation Systems and participated in a variety of projects dealing either with traffic engineering related research or continuing education short courses for transportation officials. Research activities included projects dealing with freeway corridor operations, intersection capacity, freeway traffic surveillance, highway geometric design consistency and testing of street lighting luminaires. The author also participated in the preparation of two short courses and a lighting handbook for the Federal Highway Administration and a traffic engineering short course for the Georgia State Department of Transportation.

While a staff member of the Institute, the administrative structure of the Institute and the management techniques employed by a number of principal investigators, program heads and division heads were observed. In a number of instances, situations at TTI very nearly paralleled textbook examples encountered in the courses required by the Doctor of Engineering program.

Having been employed as an engineer for over ten years at the time this report was written, the author had experienced several employment opportunities and based on this knowledge was preparing for a career in higher education. This led to the formulation of a number of career goals regarding teaching proficiency, contribution to the field of engineering, professional recognition, and university governance. To attain these goals, an number of objectives were estabished with regard to obtaining a doctoral-level degree, becoming a registered land surveyor, consulting, conducting research, publishing, participating in professional societies and serving on department, college and university committees. It is anticipated that the Doctor of Engineering degree will lend itself to the attainment of these goals.

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APPENDIX A --

TEXAS TRANSPORTATION INSTITUTE PROJECT ASSIGNMENTS

Assignment No. 1

Study Title: "Corridor Analysis for Level of Service Design"

Research Study Number: TTI-2-10-73-30

Sponsor: The Texas Department of Highways and Public Transportation in Cooperation with the U.S. Department of Transportation, Federal Highway Administration

Principal Investigator: Dr. N. J. Rowan

Duration: September 1972-August 1975

Report Title: CORRIDOR ANALYSIS FOR LEVEL OF SERVICE DESIGN

Report Number: 30-3F, Texas Transportation Institute

Report Authors: N. J. Rowan and Donald A. Andersen

Report Abstract

Research was conducted to improve the design process for transportation corridor facilities. Part of the research dealt with identifying and evaluating the current design recommendation process, while another phase dealt with functional classification, qualitative measures of traffic service, and the effects of midblock access on traffic operations.

Comments

This research effort was already underway when the author joined the Texas Transportation Institute. The author assisted in the data collection phase and supervised various graduate and undergraduate students in this effort. One of the major findings of this study was a methodology for the functional classification of arterial streets within an urban corridor. This was accomplished by observing nine sections of arterial streets in the city of Houston and classifying these streets according to eleven characteristics on a five-level semantic differential scale (Table A1).

Based on these observations and other arterial street design experience, design criteria were formulated for five types of arterial streets. These street types range from those which provide mainly access to property to those which provide for mostly through traffic (Table A2).

Table A1. Limits of Semantic Differential Scales.

CHARACTERISTIC/ROAD TYPE	ACCESS 1	2	3	4	THROUGH 5
ADT	< 10,000	10-20,000	20-30,000	30-40,000	> 40,000
PHV/½ADT	< 9%	9.0-10.9	11.0-12.9	13.0-14.9	≥ 15.0
Curb Cut Ratio	≥ 40	30-39	20-29	10-19	< 10%
Curb Cuts/Mile	> 50	30-50	15-30	5-15	0-5
Intersections/Mile	> 16	12.5-16.0	8.5-12.4	4.1-8.4	≤ 4
Signalized Intersections/Mile	> 12.0	9.5-12.0	6.5-9.4	4.1-6.4	≤ 4.0
Number of Lanes	< 4		4		> 4
Lane Width (feet)	10		11		≥ 12
Speed Limit (mph)	< 30	30	35	40	≥ 45
Lane Configuration	Two-Lane Undivided	Undivided Multilane	Undivided with Left turn lanes at major intersections	Continuous Left Turn Lanes	Divided w/ left turn lanes and raised median
Median Openings/Mile	> 20	15-20	10-14	5-9	4

Table A2. Suggested Design Criteria for Various Arterial Street Functions.

	ARTERIAL TYPE				
	Access → Through				
	1	2	3	4	5
Through Lanes (Number)	< 4		4		> 4
Median Openings/Mile	> 20 or No Median	16-20	10-15	5-9	≤ 4
Left Turn Lanes	None	Few	Major Intersections	2-way left turn lane	All Intersections
Curb Cuts (Per Mile)	50	30-50	15-30	5-15	0-5
Intersections/Mile	> 16	13-16	9-12	5-8	≤ 4
Signalized Intersections/ Mile	> 12	10-12	7-9	5-6	≤ 4
Speeds	< 30	30	35	40	45

Assignment No. 2

Study Title: "Human Factors Requirements for Real-Time Motorist Information Displays"

Research Study Number: DOT-FH-11-8505

Sponsor: Department of Transportation, Federal Highway Administration, Offices of Research and Development

Principal Investigator: Dr. Conrad L. Dudek

Co-Principal Investigator: Dr. R. Dale Huchingson

Duration: June 1974-February 1978

Report Title: VOL. 9, A STUDY OF PHYSICAL DESIGN REQUIREMENTS FOR MOTORIST INFORMATION MATRIX SIGNS

Report Number: FHWA-RD-78-13

Report Authors: C. J. Messer, W. R. Stockton, J. M. Mounce with contributions by D. A. Andersen and J. M. Turner

Abstract

The purpose of this study was to identify the physical design requirements of changeable message lamp matrix signs. Design characteristics addressed include sequential and run-on displays, message length, word per line, number of lines, display rates, legibility, bulb loss, and symbolic substitution. Effects of driver workload were also addressed.

The studies were conducted first in a laboratory equipped with a rear projection screen and subject response controls. Slides and motion picture film were used with controlled exposures to obtain

subject responses. Percent correct response was the evaluation criterion for all variables except symbolic substitution which related to association.

Selected laboratory results were subjected to limited field validation in a controlled driving environment. The field studies considered subject performance under both "unloaded" and "loaded" conditions.

Sequential display formats appeared to be considerably superior to run-on formats. Several combinations of message length, words per line and number of lines were tested. Certain combinations showed marked superiority over other combinations. A display rate of 0.5 seconds per word appeared to be the fastest acceptable for four-word messages, with 1.0 seconds/word very near optimum for both four-and eight-word messages. The 85th percentile legibility distance of the 18-inch lamp matrix sign was about 630 feet, or 35 feet/inch of letter height. Effects of bulb loss were more pronounced on unfamiliar drivers than on familiar; 10 percent loss appeared tolerable. Acceptable association was found between matrix symbols and graphic symbols, except for curved symbols.

Comments

(This assignment is discussed in Chapter III of this report).

Assignment No. 3

Study Title: "Effects of Design on Operational Performance of Signal Systems"

Research Study Number: TTI-2-18-75-203

Sponsor: The Texas Department of Highways and Public Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration

Principal Investigator: Dr. Carroll J. Messer

Duration: September 1974-August 1975

Report Title: A STUDY OF THE EFFECTS OF DESIGN AND OPERATIONAL PERFORMANCE OF SIGNAL SYSTEMS--FINAL REPORT

Report Number: 203-2F, Texas Transportation Institute

Report Authors: Carroll J. Messer, Daniel B. Fambro, and Donald A. Andersen

Abstract

This report presents the findings of a research project entitled "Effects of Design on Operational Performance of Signal Systems" sponsored by the State Department of Highways and Public Transportation in Texas in cooperation with the U. S. Department of Transportation, Federal Highway Administration Areas covered include the following: peaking characteristics of volumes at intersections in Texas during rush hour traffic conditions, left turn capacity of an approach having no protected signal phasing as related to opposing traffic volumes and intersections of different geomtric design, effects of signal phasing and length of left turn bay on intersection approach capacity, and development of a new field evaluation technique for signalized intersections. In addition research was conducted to improve the Department's PASSER-II signal progression program. Platoon movement along an arterial street and the effects of progression on vehicle delay are investigated.

Comments

(This assignment is discussed in Chapter III of this report).

Assignment No. 4

Study Title: Evaluation and Testing of Roadway Lighting Luminaires

Research Study Number: IAC 74-75, 75-76, and 76-77

Sponsor: The Texas Department of Highways and Public Transportation

Principal Investigator: Dr. N. J. Rowan

Duration: Ongoing

Report Title: (Luminaire field test results in the form of tabular data and iso-footcandle diagrams were provided to the sponsor as individual tests were completed).

Comments

These tests were conducted primarily to verify that luminaires supplied by various manufacturers actually emitted the pattern and amount of light purported by the company's literature. The results of these tests determined whether the highway department would allow a particular manufacturer to bid on a specific lighting job. Due to the significance of these tests both from the manufacturer's and highway department's point-of-view, the author personally supervised the installation of the luminaires on the light supports at the Texas A&M Research Annex. He also oversaw the data collection step in which illumination levels were recorded on a 25 x 30-foot matrix as formed by the pavement joints in the vicinity of the luminaire. Finally, iso-footcandle diagrams were drawn by students workers and copies were provided to the highway department.

From an internship experience standpoint the author came to one important realization during the assignment; that is, a supervisor or manager must be willing to let his subordinates assume responsibility for certain tasks. When the author was first put in charge of these lighting studies he was greatly concerned with making sure that everything was done correctly and for this reason he installed the luminaires, collected the data and prepared the drawings. However, after having taken Mgmt 655 the author came to the realization that these tasks were in actuality below his skill level and his main task should be that of supervising the student technicians. After delegating much of these activities to others, the author was pleased to note that the students, once given responsibility for a specific task, felt a greater sense of accomplishment and did a commendable job with minimal supervision. This "If-you-want-something done-right, do-it-yourself" trap is easy to fall into but should be avoided if one is to become an efficient manager of people.

Assignment No. 5

Study Title: "Development and Evaluation of On-Freeway Traffic Control Systems and Surveillance Techniques"

Research Study Number: TTI-2-18-76-173-1

Sponsor: The Texas Department of Highways and Public Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration

Principal Investigator: William R. McCasland

Duration: September 1975 - August 1977

Report Title: "ALTERNATE DESIGNS FOR CCTV TRAFFIC SURVEILLANCE SYSTEMS"

Report Number: 173-1, Texas Transportation Institute

Report Authors: Donald A. Andersen and William R. McCasland

Abstract

This report is one of a series that present the findings of a research project entitled "Development and Evaluation of On-Freeway Traffic Control Systems and Surveillance Techniques" sponsored by the State Department of Higways and Public Transportation in Texas in cooperation with the U.S. Department of Transportation, Federal Highway Administration. Areas covered include the following: testing and evaluation of low light level television cameras for traffic surveillance, use of television traffic surveillance systems during hours of darkness, low volume incident detection using television, and alternatives for the location of the cameras relative to the roadway.

Comments

(This assignment is discussed in Chapter III of this report).

Assignment No. 6

Study Title: "Highway Geometric Design Consistency Related to Driver Expectancy"

Research Study Number: DOT-FH-11-9230

Sponsor: Department of Transportation, Federal Highway Administration, Office of Research and Development

Principal Investigator: Dr. Carroll J. Messer

Duration: January 1977-June 1978

Interim Report Title: LITERATURE REVIEW AND ANALYSIS OF HIGHWAY GEOMETRIC DESIGN AS RELATED TO DRIVER EXPECTANCY

Report Authors: C. J. Messer, R. J. Koppa, D. A. Andersen, R. Q. Brackett and J. M. Mounce

Final Report Title: HIGHWAY GEOMETRIC DESIGN CONSISTENCY RELATED TO DRIVER EXPECTANCY, Vol. II Research Report

Report Number: FHWA/RD-81/036

Abstract

This volume, the second of a four-volume final report, describes research conducted to develop a procedure for identification and correction of inconsistent geopmetric highway elements and features that occur on non-freeway facilities. Highway design elements and groups of elements (features) judged to be potentially inconsistent were enumerated and evaluated. A procedure for assessing the consistency of existing or proposed designs was prepared. A recommended cost-effectiveness methodology was presented.

The data base included a set of 140 geometric features located in Georgia and Texas and identified by field engineers to be experiencing operations and safety problems. These sites were systematically evaluated. Over 70 subject drivers and 21 research and highway design engineers reviewed some or all of these features. Geometric complexity of the features, sight distance, feature separation distance, speed and vehicle conflicts were noted to contribute to expectancy violations.

Comments

This author terminated his employment with the Texas Transportation Institute before this project was completed. He did, however, participate in the earlier tasks which included an extensive literature search and field studies in which sections of roadway were filmed and video taped to detect and evaluate geometric design inconsistencies.

Assignment No. 7

Project Title: "Georgia Department of Transportation Traffic Engineering Short Course"

Sponsor: Georgia Department of Transportation

Co-Principal Investigators: Dr. N. J. Rowan and Dr. Donald L. Woods

Contributing Authors: Donald A. Andersen, et. al.

Comments

This three week traffic engineering short course was written for and presented to personnel of the Georgia Highway Department. Sections of the notes were written by various authors or adapted from previous courses developed by the Texas Transportation Institute. The author of this report was primarily responsible for assembling the course notes and preparing the accompanying visual aids for the course which ultimately was presented by Drs. Woods, Rowan and Stover. The course was divided into ten sections as shown in Table A3.

Table A3. Georgia Short Course Outline.

I.	Traffic Analysis
II.	Signs and Markings
III.	Traffic Safety
IV.	Accident Records, Studies and Analysis
V.	Traffic Signals
VI.	Urban Traffic Control Programs
VII.	Roadway Capacity
VIII.	Freeway Operations
IX.	Roadway Design
X.	Public and Legal Relations

These courses notes were later modified and used in regularly scheduled courses in the Civil Engineering Department at Texas A&M University.

Assignment No. 8

Project Title: "Urban Traffic Operations Training Programs"

Contract Number: DOT-FH-11-8510

Sponsor: U.S. Department of Transportation, Federal Highway Administration, National Highway Institute, Office of Development and Office of Traffic Operations

Principal Investigator: Dr. N. J. Rowan

Comments

This project resulted in the preparation of a student notebook, instructor's notebook and visual aids for a one week short course entitled, "Alternatives for Improving Urban Transportation--A Management Overview". The principal instructors for the course was were N. J. Rowan, D. L. Woods and V. G. Stover. Ultimately, this course was presented by these individuals at a number of regional locations throughout the United States.

The author of this report wrote the preliminary draft for Chapter 9, Bicycling as an Urban Transportation Mode, and Chapter 11, Alternatives for Improving Pedestrian Facilities. In addition, the author assisted in editing the course notes and preparing visual aids. The topics covered in this course are listed in Table A4.

Table A4. Table of Contents for Urban Transportation Course.

Chapter 1 -- Introduction of Course
Chapter 2 -- Alternatives for Transportation Improvement
Chapter 3 -- The Urban Transportation Problem
Chapter 4 -- Factors Influencing Urban Transportation Needs
Chapter 5 -- Transportation Pricing
Chapter 6 -- Peak Period Demand Management
Chapter 7 -- Ridesharing Programs
Chapter 8 -- Improving Public Transportation
Chapter 9 -- Bicycling as an Urban Transportation Mode
Chapter 10 -- Improving Urban Goods Movement
Chapter 11 -- Alternatives for Improving Pedestrian Facilities
Chapter 12 -- Alternatives for Improving Traffic Operations
Chapter 13 -- Freeway Operations Management
Chapter 14 -- Transportation Alternatives and the Street Network

Further Results

The notes from this course were subsequently summarized and published by the U.S. Department of Transportation, Federal Highway Administration, Offices of Research and Development, Implementation Division under the title, "Alternatives for Improving Urban Transportation--A Management Overview." This publication is Technology Sharing Report 77-215.

Assignment No. 9

Project Title: "Texas Governor's Office of Traffic Safety Traffic Engineering Short Course"

Sponsor: Texas Governor's Office of Traffic Safety

Presentations: Huntsville, Texas, September 17, 18, & 19, 1974
Mesquite, Texas, October 8, 9, & 10, 1974

Comments

On each of the above dates the author of this report assisted Donald L. Woods and James H. Dozier in presenting a traffic engineering short course to local transportation officials. The course had been written previously and was an ongoing effort of the Texas Transportation Institute. A typical agenda for the three-day course is shown in Figure A1.

This assignment provided the author with his first experience in presenting short course type material to what was usually a greatly varied audience, anywhere from city mayors and police chiefs to registered engineers. The author gained some valuable experience in speaking before a group, using visual aids and fielding questions from the participants.

Figure A1. Agenda for Traffic Engineering Short Course.

TEXAS TRAFFIC SAFETY ADMINISTRATION
TRAFFIC ENGINEERING SHORT SCHOOL

Huntsville, Texas
September 17, 18, & 19, 1974

DAY		TOPIC	SPEAKER
Tuesday	I.	Introduction to the Course	Woods
	II.	Traffic Control Devices: General	Woods
	III.	Traffic Control Devices: Markings	Andersen
	IV.	Traffic Control Devices: Signs A	Andersen
		Traffic Control Devices: Signs B	Woods
	V.	Traffic Control Devices: Signals A	Andersen
Wednesday		Traffic Control Devices: Signals B	Woods
	VI.	Volume and Speed Studies	Andersen
	VII.	Accident Studies and Analysis	Woods
		Accident Workshop	Andersen
Thursday	VIII.	Administration of Traffic Functions	Andersen
	IX.	Pedestrian Survival	Woods
	X.	Tort Claims	Dozier
	XI.	Public Relations in Traffic Management	Woods
		Closing Remarks	

Assignment No. 10

Project Title: "Roadway Lighting Handbook"

Project Number: DOT-FH-11-8832

Sponsor: U.S. Department of Transportation, Federal Highway Administration, Office of Development, Implementation Division

Principal Investigator: Dr. Ned E. Walton

Duration: February 1976-June 1977

Report Title: ROADWAY LIGHTING HANDBOOK

Report Number: Federal Highway Administration Implementation Package 78-15

Report Author: Ned E. Walton

Contributing Authors: Neilon J. Rowan, John M. Mounce, Donald A. Andersen and Anton Huber

Organization of Handbook

The handbook was intended to serve as a guide in virtually all aspects of planning, designing, and operating roadway lighting systems. To accomplish this the following outline was used:

- Introduction
- Understanding Visibility Requirements
- Analyzing Lighting Needs
- Selecting Lighting Equipment
- Selecting the Lighting System Configuration
- Designing the Lighting System
- Designing the Lighting Hardware
- Operating and Maintaining the Lighting System
- Analyzing the Economics of the Lighting System

Comments

This author contributed to the project in three areas:

- Prepared much of the bibliography
- Toured lighting facilities in Hendersonville (North Carolina), Milwaukee, Chicago and Kansas City and met with lighting experts to determine state-of-the-art technology, and
- Wrote chapters on Designing of Lighting System and Designing the Lighting Hardware.

Assignment No. 11

Project Title: "Safety Design and Operational Practices for Streets and Highways"

Contract Number: DOT-FH-11-9149

Sponsor: U.S. Department of Transportation, Federal Highway Administration, Office of Development and National Highway Institute

Principal Investigator: Dr. N. J. Rowan

Contributing Author: Donald A. Andersen, et. al.

Comments

This course, written by members of the Texas Transportation Institute staff, was ultimately presented at a number of locations throughout the United States. Course materials included a student notebook, instructor's guide and visual aids in the form of slides and movie films. The author's contributions to and experiences derived from this effort are summarized in Chapter 3 of this report.

Proposals Authored

While employed by TTI the author participated in the preparation of several research proposals:

1. "Evaluation of Glare from Following Vehicle Headlights." Ron Morris, Project Director. Submitted to the National Highway Traffic Safety Administration, July 1976.

2. "Signal Lighting System Requirements for Emergency, School Bus and Service Vehicles." Ned E. Walton, Project Director. Submitted to the National Highway Traffic Safety Administration, June 1976.

3. "Methods for Increasing Motorcycle Conspicuity." Ned E. Walton, Project Director. Submitted to the National Highway Traffic Safety Administration, June 1976.

4. "Highway Geometric Design Related to Driver Expectancy." Carroll Messer, Principal Investigator. Submitted to Federal Highway Administration, July 1976.

5. "Development of a Curriculm on the Safety Design and Operational Practice for Streets and Highways." Neilon J. Rowan, Project Director. Submitted to the Federal Highway Administration, April 1976.

Of these proposals only the last two were ultimately successful resulting in contracts being awarded to TTI. The author formed several conclusions as a result of this exercise in proposal writing. First, a proposed must be technically sound to be seriously considered by the sponsor. Although it may seem impressive to include 25 pages of "boiler plate" describing the organization's facilities and past accomplishments, critical proposal evaluators are actually looking for specific ideas on how the problem will be addressed. Also, in writing a technically sound proposal, much of the later research effort is actually accomplished before the project is started.

Secondly, the sponsor looks very critically at the credentials of the proposed staff. In several proposals the staffing plan include a "big name" researcher at a minimum time commitment such as 10% with a number of junior TTI personnel as task directors. This arrangement apparently did not suit the sponsors who preferred a larger commitment from the proposed principal investigator.

These experiences in proposal writing, which at the time were somewhat demoralizing, provided the author with considerable insight in the areas of proposal writing and evaluation.

APPENDIX B --

PROFESSIONAL EXPERIENCE AT

THE NEBRASKA DEPARTMENT OF ROADS

After completing his Bachelor of Science in Civil Engineering in March, 1970, the author was employed by the Nebraska Department of Roads at the Central Office in Lincoln, Nebraska. His first assignment as part of the rotational training program was in the Traffic Engineering Division where the author gained experience in the areas of traffic studies and the design of traffic signs, signals and markings. He also participated in the design of high-mast lighting installations for several rural interchanges on the Interstate Highway System.

The Department of Roads assignment was interrupted in January, 1971, by a seven-month tour of duty in the U.S. Army, during which time the author was trained as a Radio-Teletype Operator. In July 1971 the author was returned to reserve status in the Nebraska National Guard and resumed his employment with the Department of Roads, this time in a permanent position in the Traffic Engineering Division.

The author's primary responsibility during this period was in the traffic studies area where he reviewed requests for traffic engineering assistance, scheduled traffic studies, and summarized the study findings. Results of the studies and recommendations were reported to his supervisor, the head of the Traffic Studies Section and ultimately to the State Traffic Engineer. Where other governmental agencies such as city councils or county boards were concerned the author was often requested to present the study results and recommendations to these officials at their regularly schedule meetings. It was from experiences of this type that the author realized the maxim, "Never try to sell a speed zone between the salad and main course of a meal at a closed city council session."

During this time the author was also responsible for the direct supervision of three full-time data collectors plus three more student summer employees. It was in this capacity that the author acquired his first managerial skills sometimes through trial and error without having had the formal education resulting from the Doctor of Engineering program.

In September, 1972, the author requested educational leave to attend the Pennsylvania State University to pursue a Master of Engineering. This study was financed in part by a Federal Highway Administration Safety Fellowship. Upon his return to the Department of Roads in September, 1973, the author was again assigned to the Traffic Engineering Division. Considerable political upheaval at various levels of state government plus limited opportunity for advancement within the Traffic Engineering Division lead to the author's resignation in February, 1974, to join the Texas Transportation Institute.

In retrospect, the author's experience with the Department of Roads reinforced his ability to work with people. This was primarily due to the extensive contact with city, county and other state officials which the author thoroughly enjoyed.

APPENDIX C --
PROFESSIONAL EXPERIENCE AT
NORTH DAKOTA STATE UNIVERSITY

The author held the position of Assistant Professor of Civil Engineering at North Dakota State University (NDSU) from August 1977 until August 1980. Although the author was hired into a tenure track position with only a Masters degree, it soon became apparent that is was in his best interest to obtain a doctoral level degree if he wished to stay in higher education and therefore he requested and was granted a leave of absence to return to Texas A&M University. The following is a summary of the author's professional activities while at NDSU.

Instructional Activities

Classroom Teaching

While at NDSU the author taught the following courses:

CE 101 -- Introduction to Engineering

CE 204 -- Surveying

CE 251 -- Route Surveying

CE 309 -- Fluid Mechanics

CE 415 -- Systems Engineering

CE 454 -- Geometric Highway Design

CE 496 -- Advanced Surveying

CE 581 -- Highway Traffic Engineering

The author initiated the Geometric Highway Design course and collaborated with Professor Ken Markve in establishing the Advanced Surveying course.

Continuing Education

In addition to his classroom teaching activities, the author prepared and presented a three-day traffic engineering short course sponsored by the North Dakota State Highway Department once during March 1980 and again in May 1981. The content of this course was tailored primarily for technicians and entry-level engineers (Figure C1).

Research Activities

The author along with Dr. James L. Jorgenson of the NDSU Civil Engineering Department conducted research in the area of the flexible pavement performance. The results of this research effort sponsored by the North Dakota State Highway Department in cooperation with the Federal Highway Administration was reported in the publication, "Pavement Performance from Historical Data." The standard title page of this report including the abstract is enclosed for the reader's information (Figure C2).

After reviewing this report the highway department contracted with the author to provide full documentation of the computer programs in order that their personnel could more fully utilize the data base which had been developed. This additional work was completed during the summer of 1980 resulting in the publication, "Manual for Using Pavement Performance Evaluation Techniques (MUPPET)."

Figure C1. North Dakota Short Course Format.

	Tuesday	Wednesday	Thursday
8:30		Session 4 - Traffic Studies for Signals	Session 9 - Accident Records and Studies
:45			
9:00			
:15			
:30		Session 5 - Workshop on Signal Warrants	Break
:45			Session 10 - Identifying and Analyzing Problem Locations
10:00	Introduction		
:15	Session 1 - Positive Guidance-Delineation	Break	
:30		Session 6 - Intersection Capacity Analysis	Session 11 - Accident Studies Workshop
:45			
11:00			
:15	Session 2 - Warning and Regulatory Signs		
:30			Critique
:45			
12:00			
1:15	Session 2 (Continued)	Session 7 - Intersection Capacity Workshop	
:30			
:45			
2:00	Session 3 - Volume Studies and Counting Procedures		
:15			
:30			
:45		Break	
3:00	Break	Session 8 - Speed Studies	
:15	Session 3 (Continued)		
:30			
:45	TOUR		
4:00			
:15			
4:30			

Figure C2. Pavement Research Project Title Page.

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. ND(3)-79(B)	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle PAVEMENT PERFORMANCE FROM HISTORICAL DATA		5. Report Date June 1980
		6. Performing Organization Code
7. Author(s) Donald A. Andersen and James L. Jorgenson		8. Performing Organization Report No.
9. Performing Organization Name and Address Civil Engineering Department North Dakota State University Fargo, North Dakota 58105		10. Work Unit No.
		11. Contract or Grant No. State Study (3)-79(B)
12. Sponsoring Agency Name and Address North Dakota State Highway Department Highway Building Bismarck, North Dakota 58505		13. Type of Report and Period Covered Final Report
		14. Sponsoring Agency Code

15. Supplementary Notes

Conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. Abstract

This report presents the findings of a research project entitled "Pavement Performance from Historical Data" sponsored by the North Dakota State Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. Historical performance data in terms of useful pavement life and surface condition were related to loading conditions, paving materials, and subgrade strength. The computer program "Statistical Analysis System" (SAS) was used to explore the relationships which existed within the data. Pavement performance was evaluated in either one of two ways. For roadways which had not been overlaid, the performance characteristic was taken as the useful life of the roadway between construction and overlay. For roadways which had not been overlaid since construction, the pavement surface condition parameters of roughness, cracking, and a combined rating were used to evaluate pavement performance.

Some of the results of this research effort were as follows. The deterioration of pavements in North Dakota is more directly related to the age of the pavement than to the daily axle loadings or soil subgrade strength. This may be related to another finding that actual pavement life usually exceeded design life. An interesting outcome of the research which was not totally explainable was that pavements in the eastern Highway Department districts had considerably less cracking than those in the western part of the state.

17. Key Words Pavement Performance, Pavement Design, Historical Data, Flexible Pavements	18. Distribution Statement No restrictions. This document is available through the National Technical Information Service, Springfield, Virginnia 22161.

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 82	22. Price

Form DOT F 1700.7 (8-69)

Other Professional Activities

During his stay at NDSU the author also participated in the following activities:

- Chairman, College of Engineering Public Events and College Relations Committee.
- Advisor, student chapter of American Society of Civil Engineers
- Advisor, Engineering Explorer Scouts
- Member, planning committee for First Annual North Dakota Traffic and Transportation Engineering Conference
- Member, Fargo-Moorhead Engineers Club and North Dakota Section of American Society of Civil Engineers.

After three years at North Dakota State University the author requested and was granted a two-year leave of absence to complete the Doctor of Engineering at Texas A&M University.

VITA

Donald Arthur Andersen

Mr. Andersen, the son of Ben and Helena Andersen, was born on June 25, 1947 at Ada, Minnesota. He and his wife, the former Sandra Elaine Morvig have one son, Jeffrey.

Mr. Andersen graduated from Ada High School in 1965 and attended Moorhead (Minnesota) State College. In 1970 he received a Bachelor of Science in Civil Engineering from North Dakota State University. He was subsequently employed by the Nebraska Department of Roads and served in the Nebraska National Guard. In 1973, Mr. Andersen was awarded a Master of Engineering in Civil Engineering at the Pennsylvania State University.

From 1974 to 1977, Mr. Andersen performed transportation research as a member of the Texas Transportation Institute staff at Texas A&M University. In 1977, he left the Institute to become an Assistant Professor of Civil Engineering at North Dakota State University from which he is currently on leave.

Mr. Andersen is a registered engineer in Texas (#38389) and North Dakota (#2021).

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The typist for this report was Ms. Caroline T. Vessels.